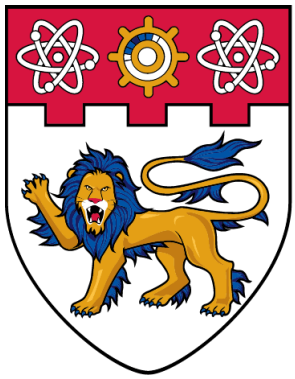

NANYANG TECHNOLOGICAL UNIVERSITY
SINGAPORE

EXPLORING VIRTUAL REALITY PAINTING TECHNOLOGY AND ITS POTENTIAL FOR ARTISTIC PURPOSES

LAM CHOON KHEE

SCHOOL OF ART, DESIGN & MEDIA

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SCHOOL OF ART, DESIGN & MEDIA

A thesis submitted to the Nanyang Technological University in partial fulfilment of the requirement for the degree of

Master of Arts (Research)

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1. ABSTRACT

With new and emerging technologies, art is becoming more fluid and taking on a myriad of novel and innovative forms. Multidimensional technologies such as virtual reality (VR) have opened up new opportunities and facilitated complex and inventive ways of creating, illustrating, and immersively experiencing art.

Since 2016, with the introduction of consumer headsets, virtual reality has been on the rise for artists and creators (Kim, 2016). Virtual reality painting and modelling apps, such as Google's Tilt Brush, have enabled users to paint visual imagery in three-dimensional space using a handheld controller that mimics painting movement, along with a range of tools, brushes, and paint effects. Once virtual reality painting allowed for 3D spatial experiences, the artistic process has significantly been impacted.

This thesis discusses the practical effect of virtual reality painting technology on new media artists who have previously worked with digital media, but have since expanded their practice into virtual reality. The research scope investigates how this new medium of virtual reality affects the creative processes of artists, and aims to understand the creative potential of virtual reality technology as an artistic medium.

2. INTRODUCTION

Virtual reality is a technology that allows the user to immerse themselves in a 3D simulated environment and interact with virtual objects. Generally, virtual reality systems utilize head-mounted displays or multi-projected environments to generate visual immersion and auditory stimulation, simulating the user's physical presence within a virtual environment. This new immersive viewing experience, which provides

a redefined sense of space and dimension, has the potential to change the way people experience and create art. Exploring an artwork in a 3D virtual space can be seen as "more intuitive and natural" as compared to the experience of a linear medium (Engasser, 2016).

Since the early development of virtual reality in the 1960s, the focus of research in this field has primarily been on the technical aspects of the medium (Bolas, 2001). The potential of virtual reality as a tool for artistic expression has not been explored to a great extent, because it has historically been used primarily for human-computer interaction rather than artistic purposes. Consequently, it is essential to examine the mechanisms of virtual reality to understand its potentiality as an artistic mode of expression, and how it impacts artistic creation.

Several new media art theorists, artists, and designers have regarded virtual reality as an ideal medium for creating a profound sense of immersion in the viewer (Chittenden, 2018). Canadian artist Char Davies and her artwork *Osmose* (Davies, 1995) demonstrate the significance of space perception in artistic explorations within virtual reality. In her virtual reality environment installation, the viewer uses a head-mounted display and a motion-tracking vest to enter a virtual world and experience metaphorical aspects of nature, created using semi representational aesthetics, translucent textures, and flowing particles. Through the lens of *Osmose*, we are shown a myopic vision of a dreamworld that proves virtual reality can indeed be used to express artistic ideas.

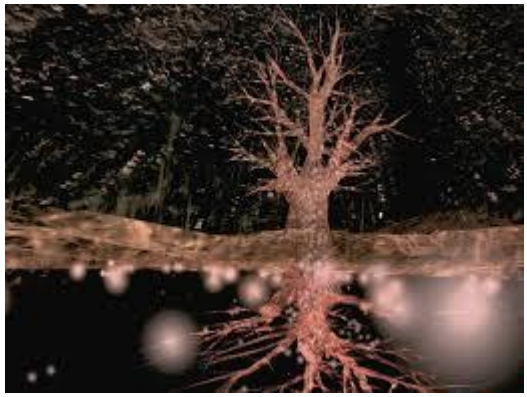

Figure 1: Char Davies, *Osmose*, 1995

As virtual reality opens possibilities of collaboration, it is appealing not only to established artists but also to a new generation of aspiring artists (Paul, 2015). Oculus Rift and HTC Vive were the first consumer headsets to hit the market in early 2016, making it easier for artists to utilize this technology (Kim, 2016). More artists have begun to work with virtual reality, creating artworks with distinctive immersive and interactive attributes, which would be almost impossible or much harder to achieve using other mediums.

Tilt Brush, a virtual reality painting app developed by Skillman & Hackett in 2014 and subsequently acquired by Google in 2015, introduced a new and innovative medium for artistic expression upon its release in 2016. From a palette of brushes and colours, users can create 3D paintings using a controller. One also has the option of using traditional paint colours or materials with textures and volumes. Since then, creators of all types of sociocultural backgrounds and artistic styles have discovered a new 3D experience in virtual reality. "The Tilt Brush app is intuitive enough to allow anyone to create immersive 3D artwork, and both the artist creating the piece and the viewers admiring it in the future can walk through the artistic environment" (Engasser, 2016).

However, there are several drawbacks to the integration of virtual reality into the art community, primarily limited accessibility. Not all users have access to the necessary equipment, such as virtual reality headsets and specialized software, required to enter virtual spaces. The device limitation of only allowing one viewer or creator at a time, as well as the expense involved with these types of equipment, deters individuals from using virtual reality for their art creations (Artfinder, 2021).

Furthermore, virtual reality technology was initially developed for military and medical applications, rather than for creating artwork. The military and medical fields acknowledged its potential alternative uses, and virtual reality has since expanded to numerous industries. Today, it finds applications in gaming, entertainment, architecture, education, training, therapy, and even remote collaborations. In her master's thesis on the artistic medium of virtual reality, Bokyung Kim concludes that "the majority of virtual reality experiences have been designed without enough consideration regarding the aesthetic pleasures the medium could deliver to users" (Kim, 2016). Even though these virtual reality technologies offer significant opportunities for artists, the art world has been sceptical of these new arrivals into its established frameworks (Stewart, 2017). It raises questions as to whether virtual reality can truly fulfil an artist's potential, eventually affecting its creative process.

3. AIM AND OBJECTIVE

My research objective is to explore virtual reality artists' practices and identify how virtual reality transforms the artistic process. The theoretical basis of this research includes investigating virtual reality content and technology to determine the perceived advantages and challenges of such a technology in creating art.

This research also aims to contribute new academic knowledge by conducting a case study on virtual reality artists such as The Sabby Life. She is a traditional oil-on-canvas artist who transitioned to using virtual reality as a medium for her work. In *Da Vinci Paints the Mona Lisa* (2018), she recreated the iconic *Mona Lisa* (c. 1503–19) painting as a walk-in virtual reality experience (Sabrina, 2023). In several ways, her artwork is compelling enough to be investigated. It is the first digital and virtual work of a traditional oil-on-canvas painting. The artwork also offers an interactive potential that allows the audience to view the work as an idle observer in virtual reality, and involves them with a sense of being part of the process.

Figure 2: Sabrina (The Sabby Life), *Da Vinci Paints the Mona Lisa*, 2018

This research examines factors that influence the artists' decisions to use specific techniques in their processes. The findings of the research will discuss the potential of virtual reality in art creation and the creative process for such artists, with reference to their work.

4. RESEARCH QUESTIONS

- What is the potential of virtual reality painting technology for artistic, interactive, and collaborative purposes?

- What are the limitations of virtual reality painting technology that impacts artists' creative processes?

Sub-questions :

- What are the features of virtual reality that attract artists to use it for their practice?
- What challenges and difficulties do artists face when using virtual reality in their work? Which of these are the most significant?

5. LITERATURE REVIEW

The purpose of this literature review is to identify and evaluate the growing interest in virtual reality as an art medium, including recent uses of virtual reality for artistic creation and the impact it has on artists.

I have surveyed books, journals, scholarly articles, and non-academic sources relevant to virtual reality studies, and have evaluated these works in respect of the research questions. This chapter reviews my selection of key sources that includes all relevant aspects of virtual reality and virtual reality painting.

5.1. Introduction of Virtual Reality

This chapter covers the definition and history of virtual reality, and describes the emerging technologies. Virtual reality has been around for more than 20 years. It started as a conceptual idea, and, like most technologies, virtual reality devices are constantly improving.

- 5.1.1. Definitions of Virtual Reality

There is a broad definition for the term “virtual reality”: it is often alluded to as a reality that immerses users into a 3D environment, created by a computer, and allows them to interact in that virtual world. Over the past decade, however, it has been used in a different context (Paul, 2015). In the fifteenth century, “virtual” was

used to mean “anything that exists in essence or effect, but not in fact or created by a computer.” It was in the 1950s that the term “virtual reality” first came into use to describe a computer-simulated environment that a person can interact with in a seemingly real way (Ethmology, 2022).

Also, when it comes to virtual reality, it should be viewed in terms of two important concepts: Telepresence and Cyberspace. Both have a strong connection with virtual reality but are based on different contexts.

Telepresence is a type of virtual reality simulation that reproduces the essence of a real but remote experience (as measured by distance or scale). It refers to the ability to use virtual reality to feel as though you are present in a different location. For example, you can use a virtual reality headset to travel to a different location without leaving your room. Providing another, more specific definition, developer Sharmistha Mandal found that telepresence occurs when “at the worksite, the manipulators have the dexterity to allow the operator to perform normal human functions; at the control station, the operator receives sufficient quantity and quality of sensory feedback to provide a feeling of actual presence at the worksite” (R. Held, 1993).

Cyberspace refers to an artificial world that can be accessed using technology. William Gibson first introduced the term “cyberspace” in his 1982 short story “Burning Chrome”, where he described it as “a consensual hallucination experienced daily by billions of legitimate operators, a graphics representation of data abstracted from the banks of every computer in the human system”. The word “cyberspace” is now more commonly used to describe virtual reality environments and the internet. It refers to a digital realm where users can interact with data, text, images, and

immersive experiences through various devices such as computers, laptops, tablets, and smartphones. In the context of virtual reality, cyberspace represents the simulated environment in which users can immerse themselves, interact with virtual objects, and engage with digital content in a more immersive and interactive manner. The evolution of the term aligns with the advancements in virtual reality technology, which aim to create realistic and immersive digital worlds for users to explore and interact with. (Mandal, 2013).

The term "virtual reality" was coined by Jaron Lanier, the founder of VPL Research who developed some of the first few commercially available virtual reality devices in the late 1980s. This new medium was referred to as a collection of virtual reality technology devices, such as VR headsets and wired gloves. Hence, the focus on the term "virtual reality" is technological (Steuer, 1992).

Nevertheless, researchers have a different viewpoint on the term "virtual reality." Doctoral candidate Jonathan Steuer (1992) argued that a device-driven definition of virtual reality is untenable as it lacks a conceptual framework in which virtual reality can vary. Without a precise theoretical dimension for study, it is challenging to conduct research that looks at the similarities and differences between various virtual reality devices, or to compare it against other forms of media. Instead of defining virtual reality as a hardware system, Steuer stated that the more appropriate way to describe the term is through a perceiver experience of the simulated environment. Therefore, he defined virtual reality as a human experience, an approach that emphasizes the experiential dimension of virtual reality (Steuer, 1992).

In my study, I will be using the term "virtual reality" with a focus more on its experiential dimension rather than the technological, thus enabling me to use

perceptual processes and individual differences in determining the characteristics of virtual reality. These characteristics highlight the common features of virtual reality systems: immersion, presence, and interaction.

- **5.1.2. Characteristics of Virtual Reality**

Virtual reality has its own set of characteristics that results from the fact that users can virtually immerse themselves in another world while interacting with the content. Immersion, presence, and interactivity are considered the three most important characteristics of virtual reality (Mütterlein, 2018). The following is a brief introduction to and overview of these three main features of virtual reality systems.

The characteristic that sets virtual reality apart from other mediums is the sense of presence created by the technology. When users are immersed in virtual reality, they feel as if they are within the virtual environment.

In the context of virtual worlds, "immersion" means being utterly absorbed in a virtual environment, while "presence" refers to being aware of and experiencing a virtual environment. As there is no standard explanation for the relationship between immersion and presence, these two concepts are often confused. It has been suggested that the term "immersion" often refers to the sense of presence when associated with virtual reality. Therefore, these two terms have been used interchangeably within virtual reality literature (McMahan, 2003).

When viewed from the perspective of technology, immersion can be defined differently. Immersion is commonly regarded as an "objective and technological aspect of virtual reality", while presence is considered a "psychological factor and cognitive consequence of immersion." Slater and Wilbur (as cited in Sajjadi, 2022) defined immersion as "an objective and quantifiable description of what any given

system does provide," while German scholars Thomas Schubert, Frank Friedmann, and Holger Regenbrecht (Schubert, Friedmann, & Regenbrecht, 1998) described presence as "a state of consciousness, the (psychological) sense of being in the virtual environment."

Witmer and Singer (as cited in Sajjadi, 2022) took a different stance from them. They contended that immersion involves psychological and individual aspects as well. Their definition of immersion is "a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences." In addition, immersion is considered a necessary condition for eliciting presence. According to Witmer and Singer, immersion and involvement are both essential to experiencing presence in a virtual environment. In their view, involvement is "a psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events", and, in addition, it is also connected to other notions akin to engagement, such as Csikszentmihalyi's "flow state" (Sajjadi, 2022).

On the other hand, the concept of interaction can be defined in a way that is more direct and easier to decipher than immersion and presence. When referring to virtual reality, the term "interactivity" refers to how the digital model is related to its user. User interaction implies that they can facilitate the process of transferring information via the computer. An interactive medium is therefore one that allows users to influence and take part in determining the content and format (Inglese, 2019). In terms of human-computer interaction, Steuer defined interactivity as the degree "to which users can participate in modifying the form and content of a mediated environment in real-time" (Sajjadi, 2022).

In contrast to traditional forms of media such as print and video, which are primarily observational, virtual reality is a highly interactive medium. Users of virtual reality can influence the form and contents of the virtual environment simply by interacting with their surroundings. The degree of interactivity in each virtual reality experience is a key characteristic that sets it apart from other types of media.

The interaction we have with media technologies is an experiential one, as Laurel highlighted. She has described:

> "Media use in terms of mimesis (a form of artistic imitation typically applied in dramatic contexts), likens the relationship between user and technology to action in a play, and emphasizes the importance of encouraging the user of a technology to develop a first-person, rather than third-person, relationship with his or her mediated environment" (Steuer, 1992).

Interactivity is more than simply being able to navigate a virtual space. It is the ability to customize and alter it. The mere act of moving sensors and just moving around does not establish an interactive relationship with an environment. For a virtual world to be truly interactive, it must react to the user's actions.

By examining how these characteristics interrelate, and their impact on the user's relationship with the virtual reality experience, it becomes apparent that they offer valuable avenues for artistic exploration. The exploration of virtual reality painting technology within this context allows for a deeper understanding of how artists can utilize these characteristics to enhance their artistic expression and create unique artistic experiences.

5.2. Historical Research on the Evolution of Virtual Reality

- 5.2.1. Evolution of Virtual Reality

The history of technological innovation in virtual reality has been evolving for decades, even before the recent development of virtual reality headsets such as Oculus Rift and HTC Vive. The concept of virtual reality has been around since the 1960s, with the business-grade virtual reality tools debuting in the late 1980s (Mazuryk & Gervautz, 1999).

In his book *The Language of New Media*, computer science professor Lev Manovich made interesting points in discussing how the user's viewing experience developed and how the space of representation changed when new technologies such as virtual reality and telepresence were introduced. Virtual reality demonstrates how computer-based illusionism functions differently. As Manovich put it, "rather than utilizing the single dimension of visual fidelity, they construct the reality effect on a number of dimensions, of which visual fidelity is but one" (Manovich, 2002).

Since at least recorded history, people have created ways to incorporate their imaginations into the real world through art, literature, and, most recently, digital media. Through telling stories using virtual reality devices, such artists and inventors have explored different ways to captivate their audiences by evoking the sensation of being in another reality. That is the focus of this section: the evolutionary history of virtual reality. Despite the inherent limitations of every medium, people continue to look for a medium that is more realistic and immersive than before (Bown et al., 2017).

- **5.2.2. Early Examples of Virtual Reality**

The difficulty in defining the concept of an alternative existence contributes significantly to the lack of consensus on the exact origins of virtual reality. Even today, while scholars are aware of the emerging significance of new forms and institutions, the details are not well documented (Manovich, 2002). The growth of virtual reality has been made possible by way too many developments in concepts and technology. This simulated reality is typically experienced through visual and auditory stimuli, aiming to create an immersive and interactive environment.

The concept of the immersive experience was first introduced in the eighteenth century, when 360-degree murals and panoramas were developed. Robert Barker, a landscape artist, is credited with inventing panoramic paintings, which offered shared imagery. A rotunda was constructed in 1792 by Barker as a means of creating a sense of immersion into a different location. As a result of the advent of panoramas, still imagery became more engaging, by placing the viewer in the centre of the image, allowing them to experience it from a whole new perspective (Bown et al., 2017).

Telephones, cinematography, and phonographs emerged as groundbreaking inventions in the late nineteenth century, fundamentally transforming society in profound and multifaceted ways. These technological advancements revolutionized communication, entertainment, and cultural exchange, leaving an indelible mark on the fabric of society. A hunger for different adventures has led to the rapid development of new devices and mediums to create new experiences. One such device is the stereoscope that was invented by Charles Wheatstone in 1838. Popularized in the late 1800s and early 1900s, stereoscopic 3D photos were another unique form of entertainment. The stereoscope was a two-view device that used special lenses to project images on to a screen. Back then, before becoming a commonplace tool, the

stereoscope was the only way to experience 3D images; it was the first device to make 3D images more widely available to the public. Improvements to the stereoscope in the 19th and 20th centuries, and the eventual invention of virtual reality devices, occurred due to Wheatstone's work. His discoveries of stereoscopic images and binocular vision laid the groundwork for how virtual reality headsets would operate (Bown et al., 2017).

The idea of virtual reality began in the mid-1960s when computer scientist Ivan Sutherland introduced the concept of virtual reality to the world, describing it as a "window through which a user perceives the virtual world as if looked, felt, sounded real and in which the user could act realistically" (Cipresso, Giglioli, Raya, & Riva, 2018). He constructed an artificial world simulator, The Ultimate Display, that involved interactive graphics, force-feedback, sound, smell, and taste: the ultimate solution to virtual reality. As renaissance architect, Leone Battista Alberti wrote, the ultimate display will create the experience of a manufactured environment so precise that it becomes a gateway to the imagined world (Bown et al., 2017).

However, a concept was not enough for Ivan Sutherland. He subsequently developed the first hardware-based virtual reality system in 1968. Called The Sword of Damocles, it was the first head-mounted display with accurate head tracking and a stereoscopic display that refreshed, in real time, based on the user's head position and orientation. He demonstrated an immersive media system, featuring a virtual reality headset, that allowed the user to see various primitive 3D models from different perspectives.

Sutherland revolutionized how we interact with virtual worlds by creating head-mounted displays that let us interact with 3D environments in ways we could not

before. This was a pivotal moment in the development of virtual reality and augmented reality (AR) (Sutherland, 1968).

However, The Sword of Damocles was just a start towards early virtual reality systems. It had a primitive user interface and a simple virtual environment comprised of wireframe rooms with limited graphics (Mazuryk & Gervautz, 1999). It was deemed impractical for general use due to the bulky headsets with a low-resolution, narrow field of view (Hutchison, 2007).

In the late 1960s and 1970s, the defence industry began investing in virtual reality technology, primarily for military training, simulation, and mission planning. Their focus revolved around crafting realistic virtual environments and enhancing user experiences. Defence organizations and contractors made notable advancements in various aspects of virtual reality, including immersive displays, head-mounted devices, tracking systems, and haptic feedback. These innovations aimed to create highly immersive and interactive simulations for training purposes (Haar, 2005). Notable projects during this period include the Super Cockpit, a flight simulator developed by the US Air Force, which simulated realistic cockpit environments and provided effective training for pilots (Mertz, 2019). The research and innovation during this era played a crucial role in driving the evolution of virtual reality technology. Their advancements in hardware, simulation techniques, and user interaction laid the foundation for the subsequent development and applications of virtual reality, in which artists can explore new dimensions of artistic expression (Gobbetti & Scateni, 1998).

The development of the virtual reality system led artist and programmer Myron Krueger to establish an experiment he called Artificial Reality. Through these research

initiatives, “Videoplace” (1974), the first artificial reality environment/artwork that surrounds users and reacts to their movements, was developed (Mandal, 2013).

Due to extremely high development costs, complexities of virtual reality devices, and other challenges, these technologies did not find their way into the commercial world until the 1980s. Researchers at Jaron Lanier’s VPL Research could by then create virtual reality experiences with affordable hardware. Henceforth, VPL Research was one of the first companies to commercially introduce immersive virtual reality devices. Among these products were a glove device for interacting with the virtual world and a head-mounted display that enabled users to immerse themselves in 3D worlds. Works such as the aforementioned *Osmose* by Char Davies was created using the technologies. The predominantly software-based level of immersion and embodiment developed in Davies’s work is distinctive among the virtual reality environments developed in an art context (Paul, 2015).

- **5.2.3. The Modern Age of Virtual Reality**

As virtual reality gained traction, the early 1990s was a time of optimism. The future was bright, the content plentiful, and technology was improving at a rapid pace. The internet had only recently become mainstream, and people were excited by the prospect of virtual reality (Artdex).

The Cave Automatic Virtual Environment (CAVE) system was the first major virtual reality system to be used in a research setting. It was developed in the early 1990s by researchers at the University of Illinois Chicago with funding from the US Department of Defense. The CAVE system consisted of two large screens side by side, each of which displayed an image slightly out of focus. By wearing 3D glasses inside the CAVE, users could view 3D graphics generated by the CAVE. Objects

appeared to float in the air on the screen, and users walked around them as if they were in the real world. One of the first artworks to be created using the CAVE was *conFiguring the CAVE* (1997), by artists Agnes Hegedus, Jeffrey Shaw, and Bernd Lintermann, a form of virtual reality environment (Paul, 2015). At that time, people were fascinated to see how computer technology could generate a simulation of a physical environment (Bown et al., 2017).

It is believed that virtual reality hit its first peak between 1992 and 1995, when inflated expectations and over-enthusiasm around the technology prevailed. For example, the first-generation video game consoles from Nintendo, Sega, and Sony all boasted virtual reality capabilities of some kind (Lanier & Biocca, 1992) .

Hardware limitations were numerous, and the price of these devices would have been prohibitively expensive for the average consumer at that time. There were also significant concerns among testers about motion sickness and nausea when wearing the devices, a challenge that virtual reality systems still face in today's world (Bown et al., 2017).

Extraordinary claims made for virtual reality in the preceding decades were often accompanied by overblown expectations. The future that speculators expected was vastly different from the future that was depicted. Headsets were bulky, uncomfortable, and not very immersive; graphics were subpar as compared to what is possible with modern technology; and experiences were short in contrast to modern games. This led to disappointment of many developers who had high expectations, but insufficient financial means or technical expertise to realize them. The virtual reality industry, which was experiencing rapid growth, had become saturated, making it difficult for researchers and artists to explore the potential of virtual reality. Public

interest in virtual reality seemed to fade with the advent of the World Wide Web (Robertson & Zelenko, 2014). The internet brought in countless possibilities for art and gave everyone the ability to share their ideas with the world. With virtual reality seeming like just another possibility for artists, with so many other alternatives available to explore, the medium was easily forgotten. Although virtual reality had suffered a major set of public failures, this did not mean that it had been abandoned.

- **5.2.4. The Emergence of Commercial Virtual Reality Technology**

The popularity of virtual reality seemed to have waned after the hype, but some researchers remained hopeful it would be able to regain its status when appropriate technologies became available (Kim, 2016). Rapid advances in computer technologies and 3D graphic capabilities allowed virtual reality to remain viable for several years (Society, 2017). A decade later, the Oculus Rift headset entered the market in 2012. An immersive virtual reality device developed by Oculus VR founder Palmer Luckey, it came with realistic imagery that incorporated hand-motion technology. There was a significant improvement in image quality, and the sense of presence can only be experienced when donning the headset (Wagner, 2016).

Through the introduction of more advanced systems and improved affordability, the technology became accessible to a wider range of individuals. Oculus Rift was considered the most accessible entry point for consumers to have an immersive experience with depth perception (through stereoscopic vision) at home. These virtual reality headsets were considered revolutionary towards art creation. Many projects were produced using software such as Unity or Unreal Engine, then converted into a virtual reality–capable format (Artfinder, 2021).

In 2012, Oculus VR had success on the Kickstarter crowdfunding platform, bringing a long-awaited virtual reality experience to people around the world (Harley, 2019). In 2014, Facebook announced its $2-billion acquisition of the virtual reality company Oculus (Bown et al., 2017). A turning point for Facebook, it not only showed that the company was committed to investing in the future of technology, but it was also viewed as a further extension of Facebook's mission of connecting the world (Wagner, 2016).

Facebook cofounder Mark Zuckerberg acknowledged, around 2013, that social networking sites are going to be able to deliver a range of experiences to people through immersive technology. Just as phones have been a platform for human connection and communication, virtual reality, he said, will be no different (Chafkin, 2015).

- **5.2.5. The Technological Advancements of Virtual Reality**

Today, virtual reality technology has entered its second peak of inflated expectations. In the wake of the Oculus Rift, several companies, including Samsung, Google, and Steam, have developed their versions of virtual reality products that offer similar experiences (Bown et al., 2017).

The widespread adoption of smartphones has made it much easier to access virtual reality. In 2014, Samsung introduced a headset called Samsung Gear VR that uses a Samsung smartphone as a display and controller; in the same year, Google launched Google Cardboard, a low-cost headset created from cardboard that uses a magnet to hold a mobile phone in place. With the release of both products, virtual reality was made more accessible to the public, thus bringing more opportunities to artists.

Subsequently, in 2016, Tilt Brush was released. The app was originally developed by the company Skillman & Hackett and was subsequently acquired by Google in 2015. Earlier versions of Tilt Brush only allowed users to build on two-dimensional planes. The Tilt Brush development team, however, went on to collaborate with Google's engineers through their Artist in Residence programme. One significant result of this collaboration was the emergence of a new artistic practice that combined traditional artistic methods with the dynamic and limitless features provided by the device (Borges J. & Di Felice, 2018).

Artists such as Tamiko Thiel, from the Tilt Brush Artist in Residence programme, continued to study and work with new virtual reality painting tools to explore the spatial dimension of art. She added, Tilt Brush is an exciting tool that enables her to realize a way of working that she wanted to do for decades (Thiel, 2021). One such work done by Thiel was *Land of Cloud* (2017), a virtual reality and 3D sound installation "created with a unique brush, texture, and calligraphic gestural stroke that determines its form, appearance and composition" (Thiel, n.d.).

Technological advancements have always affected artists' ways of creating. Virtual reality has inspired several artists with its potential as a powerful means for creative expression. Historical research studies on its evolution have allowed me to examine the fundamental aspects that have accentuated the development of virtual reality capacities for art creation. Bokyung Kim anticipates that virtual reality, with its potential, could become one of the most influential forms of media in history, if we continue to explore its artistic capacity with technological advancements (Kim, 2016).

5.3. Virtual Reality Impacts on the Socioeconomic Factors

- ### 5.3.1. The Socioeconomic Aspect of Virtual Reality

Virtual reality has become an innovative technology with significant potential across a variety of industries, including the arts. Artists can now produce immersive experiences that transcend traditional creative boundaries using virtual reality technology. The unique set of tools and capabilities provided by virtual reality painting gives artists a distinct opportunity when it comes to creating 3D artwork with interactivity, which breaks free from the constraints of physical space. This innovation has ignited immense interest among artists, developers, and the audience, with its potential to revolutionize the artistic landscape (Kim, 2016).

Virtual reality in artistic practices requires a clear understanding of the socioeconomics implications, as the success of the art market depends on its ability to adapt to evolving trends. With virtual reality's growth as an art form, traditional art markets can be reshaped. The captivating and interactive qualities of virtual reality make it popular among new audiences. Simultaneously, digital technologies such as virtual reality offer museums the chance to expand their audience reach, create new sources of economic and cultural value, and stimulate the development of innovative business models. By embracing these technologies, museums can make contact with untapped audiences and contribute to both economic and cultural growth (Bakhshi & Throsby, 2010) .

Considering the potential positive impact of technology on the economy of art, it is crucial to acknowledge that the economic effect of virtual reality for artistic purposes also presents a range of challenges and considerations. As the University of South Florida's Sarah Gamboa (Gamboa, 2018) stated in her thesis, "The economic

impact technology is having on art is perceived as both positive and negative." This observation underscores the multifaceted nature of how technology's influence on the art world is perceived economically. By examining the perception and acceptance of virtual reality art in the traditional art world, we can better understand its economic dynamics, which are necessary for determining its market demand and value.

- **5.3.2. Economic Potential and Challenges of Virtual Reality: Art Industry and Gallery Experiences**

Virtual reality has significant economic potential for the art market, but it is vital to understand that there are several challenges to overcome and factors to consider when implementing this technology (Gobbetti & Scateni, 1998). A broader demographic that actively seeks out opportunities to interact with virtual reality–based artwork could be developed by increasing exposure to virtual reality experiences at places like art galleries or museums.

This heightened exposure would not only expand the audience's appreciation of virtual reality art, but also significantly impact its market demand and value. This notion is reinforced by the argument of Nicholas Serota (1996), former director of the Tate galleries, that the transformation occurring in contemporary museums is centred around a fundamental shift in the relationship between visitors and the artwork (Serota, 1996).

Virtual reality has the transformative capacity to reshape galleries and museums, offering entirely new ways of experiencing art. Museums and galleries worldwide have already begun providing virtual experiences that allow people to explore works of art from the comfort of their own living rooms. This early adoption of virtual reality has focused on utilizing the technology as a means to provide greater

access, particularly for remote visitors. This innovative approach has led to the concept of a "museum without walls" (Hooper-Greenhill, 2000), breaking down physical barriers and expanding the reach of art beyond traditional museum settings. This innovative technology addresses various limitations faced by museums, such as the inability to display certain exhibits due to space constraints or its fragility.

Additionally, virtual reality could, through simulation, assist us in visualizing environments, constructions, or objects that may no longer exist or are difficult to visit in person (Lepouras & Vassilakis, 2004). By leveraging virtual reality technology, museums can enhance accessibility, preservation, and the overall engagement of audiences with art. This fosters the growth of the art scene by introducing artworks to a broader audience, who usually would not visit galleries. This also means that real-world geography is becoming less relevant, as artists can now produce artwork for a variety of different spaces.

Virtual reality further advances this development by extending museum visitors' interaction options to a more immersive and interactive experience. Increasing numbers of galleries and museums are adopting technological innovations like virtual reality to meet the challenges of the digital age. Since early 2015, we saw that museums globally have been using virtual reality technologies. According to the Museum Innovation Barometer, a research initiative aimed at assessing the status quo of new technology and innovation in museums, 21 per cent of museums have incorporated virtual reality technology into their exhibitions, and 33 per cent plan to do so in the future (Olga Tykhonova, 2021).

One example is the Tate Modern, the London museum that showcases modern and contemporary art. In the last few years, the museum has significantly increased the

number of virtual reality artworks that it showcases to visitors. Instead of sticking with traditional methods, the museum uses virtual reality to allow visitors to get up close and personal with some of the world's most famous paintings. This lets them experience art without physically visiting the museum (Tate, 2017).

35 Locally, the National Museum of Singapore, with their recent DigiMuse initiative, has also started showcasing creative innovators and artists with digital art and innovative concepts. As Maria Shehade and Theopisti Stylianou-Lambert noted, "technologies, such as VR, have created tremendous opportunities for museums on many levels, offering alternative ways for museums to interact with their visitors" (Shehade & Stylianou-Lambert, 2020).

As such, geography has also become less relevant as artists can produce virtual reality artwork for different platforms, including the HTC Vive, Oculus Rift, and more. Some artists explore how to use virtual reality to bring art to places that do not have the resources or space for traditional exhibitions. With virtual reality, an artist could also potentially have multiple iterations of the same artwork in various locations simultaneously. Some are for display in galleries, while others are freely accessible online, enabling viewers to plunge themselves into fully articulated virtual spaces.

Immersive, 360-degree apps such as WONDER 360 were among the first to significantly use virtual reality to let the viewer explore a virtual representation of an art gallery and its artworks. These explorations could potentially transform the museum space and redefine the conventional viewing experience, which eventually affects artists' creative processes (Smithsonian, 2016). With virtual reality, artists and creators from diverse backgrounds have the opportunity to express themselves on the same virtual playing field; thus, geographic location is no longer as important when it

comes to being successful. This opens the industry to a much larger talent pool, resulting in a more diverse range of work.

The art world's incorporation of virtual reality has paved the way for innovative ways to create exhibitions and showcase artworks. As Jaron Lanier highlighted, the medium's creative possibilities and sense of exploration are important features of virtual reality (Lanier & Biocca, 1992). This further emphasizes the transformative nature of virtual reality in the artistic realm. Notably, virtual reality equips artists with unprecedented tools and capabilities, enabling them to produce immersive and interactive artworks that revolutionize their interaction with audiences and viewers. These advancements align with the optimistic outlook of investment researchers, as showcased in the Piper Jaffray Report of 2015, who forecast the thriving popularity of virtual reality as a technological trend in the next decade and beyond (Boldyreva, 2018).

- **5.3.3. The Socioeconomic Implications of Virtual Reality in Art**

The impact of virtual reality goes beyond transforming our perception and creation of art, it also extends to the socioeconomic landscape. Virtual reality art has unlimited possibilities and anticipated its ongoing role in shaping and transforming the art world (Kunnumpurath & Stephen, 2023). The realm of virtual reality encompasses multifaceted and dynamic socioeconomic factors, comprising various interconnected components. By exploring these factors, particularly the demographics of virtual reality users, we can obtain a comprehensive understanding of the complex and interconnected elements that contribute to the growth of this transformative medium, and its opportunities for artists. Income and education levels and access to technology are among the various factors covered by this exploration.

- **5.3.4. Economic Landscape of Virtual Reality in Art: Costs, Accessibility, and Inclusivity**

When measuring the socioeconomic impacts of virtual reality, expenditures associated with its use should be taken into account. Virtual reality technology requires substantial investments in hardware, software, and technical expertise, which can prove to be challenging for artists, particularly those with limited financial means. Because of the high initial expenses, widespread adoption of virtual reality is constrained, and some population groups are excluded (Bown et al., 2017).

The substantial cost of virtual reality technology may result in higher access to higher-income individuals only, whereas low-income individuals may face barriers to entry. The high expense of virtual reality headsets and associated hardware or apps for virtual reality art results in 56 per cent of virtual reality users in the US having an annual income exceeding $50,000. (Williams, 2023).

According to Jingdezhen Ceramic Institute's Han Liu, "due to the high cost of purchasing virtual reality system[s] and the physical space needed to run it, [T]ilt [B]rush is far from popular." Consequently, access to the app is limited to a small number of creative individuals, and their artwork remains out of reach for most people (Liu, 2021).

However, as technology has progressed and gained more traction, the cost of virtual reality technology has significantly decreased, making it more accessible to a larger number of individuals (Ramsier, 2019). The greater affordability of equipment such as the Oculus Rift headset has opened up virtual reality painting to a broader demographic. This economically priced headset provides an opportunity for artists and enthusiasts who may have previously felt deterred by the high expenses involved.

Reducing cost helps bridge gaps and enables artists from diverse backgrounds to fully explore the potential of virtual reality painting (Kim, 2016).

A virtual reality artwork's economic viability depends on technological advancements and audience acceptance. As technology advances, it becomes easier to access hardware and software, and improved creation tools enable artists to express themselves more effectively (Gobbetti & Scateni, 1998). As a result, more artists are attracted to the medium and new artistic expressions can be explored.

It is important to note that despite the treend towards more affordable and user-friendly virtual reality technologies, access can still be limited by economic disparities. Affordability remains relative, and what may be within reach for some is still be beyond the means of others. Even with the decrease in prices of virtual reality equipment in recent years, it is still a substantial investment for emerging artists (Dick, 2021).

As technology continues to evolve, the technology industry is constantly faced with the challenge of recouping the initial cost of development and ongoing upgrade expenses. The additional factors of software costs, regular updates, and maintenance compound the challenges faced by the industry as a whole, extending to the realm of virtual reality. With continuous technological advancements, the financial burden increases, impacting the affordability of virtual reality and other technologies, potentially causing economic disparities (Gamboa, 2018).

- **5.3.5. User Proficiency and Sociodemographic Influences**

Virtual reality technology attracts users across various age groups, with a notable concentration among individuals who possess technical proficiency.

Proficiency in using virtual reality is a crucial factor influencing the acceptance of and engagement with virtual reality experiences.

Even though virtual reality technology has advanced to become more user-friendly, operating and navigating virtual reality devices still requires some fundamental technical knowledge. Additionally, the creation of virtual reality art requires a new set of knowledge and skills. It is necessary for artists to possess proficiency in 3D modelling, animation, or programming in order to create immersive and interactive virtual reality art. Those who are unfamiliar with these technologies and skills face a steep learning curve and are limited in their abilities to create virtual reality art (Kunnumpurath & Stephen, 2023).

Age plays a significant role in virtual reality usage. Research shows that 25- to 34-year-olds are the most frequent users of virtual reality, accounting for 38.9 per cent of users, followed by 18- to 24-year-olds at 32.4 per cent. In general, young adults are more engaged with virtual reality, driven by their interests in gaming, entertainment, and immersive experiences (Williams, 2023).

In order to engage effectively with virtual reality, users also need to be familiar with fundamental technological concepts and have comfort operating virtual reality equipment. This involves knowledge of how to put on and adjust virtual reality goggles, how to interact with virtual settings and environments with controllers or hand gestures, and navigating virtual reality menus and settings.

Certain knowledge gaps can be attributed to generational differences. According to surveys conducted by the Pew Research Centre, individuals with lower levels of formal education, lower-income households, and older adults were found to be more susceptible to expressing limited or no certainty regarding their proficiency

with digital tools. Additionally, a significant number of them requested support when it came to setting up new devices (Dick, 2021).

As such, content may be unwittingly developed to primarily appeal to a particular demographic group's interests and preferences. The lack of diversity and representation in virtual reality experiences can limit the opportunity for cultural exchange and societal enrichment. Since particular socioeconomic groups are underrepresented among virtual reality users, it may be difficult for the technology to become widely adopted, and may reduce its potential influence on a range of sectors, including the arts.

The perception and acceptance of virtual reality art in the traditional art world significantly affects its market demand and value. As virtual reality continues to advance, it presents artists with exciting opportunities. It remains important, however, to recognize that the impact of virtual reality on the art world is still evolving, and may require artists to adapt and update their skills to stay relevant (Kunnumpurath & Stephen, 2023).

For example, the rise of the internet and digital networks has transformed how artists engage with their audience and receive acknowledgement. Sharing artwork online allows artists to reach a wider audience, significantly increasing their recognition levels and opportunities.

Virtual reality technology has also cut down traditional barriers to creating large format works like large-scale sculptures. Affordable 3D modelling now empowers artists to design and showcase monumental sculptures digitally, without the need for expensive materials.

Additionally, the affordability and accessibility of digital tools have democratized creative fields. For instance, subscription-based pricing and alternative software options have made powerful tools like Photoshop accessible to a broader audience.

In conclusion, advancements in technology have fundamentally transformed the socioeconomic landscape for artists. Artists now have opportunities to reach a global audience, explore new artistic possibilities, and break down financial barriers. As technology evolves, artists can anticipate even more empowering changes in the future.

5.4. Introduction of Virtual Reality Painting Application

Throughout the advancement of virtual technology, art has made a great leap forward and has experienced a major transformation. Such developments have had a profound impact on and shaped artistic expression (Hacmun, Regev, & Salomon, 2018). Because of the introduction of digital devices, the internet, and computer programmes, a brand-new form of visual art has emerged as the mainstream of contemporary art, applying to a wide range of practices: art creation in the digital or virtual space (Cui, 2017). Using computer programmes, artists now experiment with new mediums and techniques to produce more elaborate and conceptual digital art. Their technological tools range from software such as Photoshop, which allows artists to effectively manipulate media using customized tools, to virtual reality technology that enables artists to construct immersive, interactive art pieces.

The range of digital tools has also expanded greatly. New apps are being developed to allow anyone to share their creations and express themselves through art. Digital art tools have never been more accessible to those without any prior art-

making experience; they are no longer limited to professional artists as "the high accessibility and friendly user interface, have made it a common form of expression" (Hacmun et al., 2018).

With the advent of software and apps that enable virtual painting, numerous artists have been inspired and enabled to explore new possibilities and find new challenges. We have, therefore, seen the rise of a new breed of artists. In addition to their solid foundation in traditional art, they also possess a strong background in computer science and technology (Cui, 2017).

Traditional mediums such as oil, watercolour, and acrylic paintings have dominated the commercial art industry for decades. Nevertheless, the growth of painting application technology has transformed the art market in the last five to 10 years. Digital painting art has opened new development opportunities as it has evolved into a commercial and popular trend in the art market. The accessibility, affordability, and ease of use of painting application technology have also enabled a new generation of artists to pursue their passion to create digital painting art. According to Zhuhai College of Jilin University researcher Jingtao Cui, "the various forms of digital painting art as a new cultural phenomenon in recent years [show the] unique characteristics of digital art, [and] more importantly . . . the new era of artistic ideas of innovation and social culture" (Cui, 2017).

The focus of the next section will be on artistic creation for virtual reality using commercially accessible software, such as Tilt Brush. It will introduce the unique characteristics and capabilities of this new, virtual creative medium and discuss its potential and challenges for use by artists.

- **5.4.1 Characteristics of Virtual Reality as a Creative Medium**

1. Virtual Reality Art

Henry David Thoreau famously said, “This world is but a canvas for our imagination.” As a result of the development in virtual reality technologies, our world has literally become a digital canvas. It can be argued that no form of digital painting could compete with working with a brush on canvas. However, virtual reality goes beyond the typical digital paintings, as one can paint in a 3D virtual space that serves as one’s canvas.

The key characteristic of virtual reality art is the flexibility to move in 3D space while simultaneously creating art with virtual materials. In contrast to traditional mediums like painting and photography, virtual materials are not constrained by the limitations of physics (Hacmun et al., 2018). Virtual reality lends itself to artistic expression in ways that a 2D canvas does not. As a medium, virtual reality enables artists to explore new artistic territories. The presence of a virtual reality headset, movement controllers, and other immersive technology enables users to feel as if they are in a virtual world, and allows them to manipulate objects and materials using their hands, arms, and bodies.

2. Artistic Virtual Reality Environment

Artistic Virtual Environments, also known as creative or artistic virtual reality, are intended for artistic creation, personal expression, and immersive experiences. According to Bowling Green State University’s Guy W. Zimmerman and Dena E. Eber (Zimmerman & Eber, 2001), unlike commercial virtual reality installations, artistic virtual environments are designed to be expressive rather than for entertainment purposes. For the creation of virtual art, artistic virtual environments

offer a safe, intuitive, and responsive platform. They are often used by artists, architects, and designers who are interested in exploring immersive and expressive content.

In virtual reality, a one-of-a-kind medium for artistic expression, artists can create a virtual environment as if it were a work of art. Through virtual reality technology, they can make people feel like they are inside the artwork. Virtual reality is continuously evolving and is as versatile as other forms of digital art. There is a variety of creative potentials: from interactive art to spherical panoramas, and to museum-quality displays. Virtual reality is, in some ways, an evolution of traditional 2D and 3D art styles, taking them to the next level by offering the ability to create and experience a wholly immersive and artistic virtual environment.

When it comes to immersion, virtual reality has significant potential. According to film director Alina Cyranek:

> "You are no longer looking at a picture, you're in the picture or the specific space. With the controller, the user is able to change or manipulate the picture and be an artist [him or] herself. There are limitless opportunities for what virtual reality can do in the world of art".

Artist Hana Auerova adds that being able to immerse your senses into an artwork is rare, and that everyone will remember that kind of immersive experience (Artfinder, 2021).

An artistic virtual environment is specifically designed to depict a work of art. Typically, these artworks are viewed using immersive display technology. The virtual reality environment can be experienced with a virtual reality device, such as the

Oculus Rift headset, as well as a confined area where movement can take place. This type of artistic environment can be created using apps such as Tilt Brush.

An embodied experience is stimulated with the use of hands and body movements. The creator must wear a head-mounted device and two wireless controllers. Both controllers to manipulate different aspects of artistic creation: one controller dominates the painting, while the other governs the colour palette and the interface menu (Artfinder, 2021).

While inside the virtual environment, the artist can freely roam around, as grids appearing in the visual display indicate when the artist is nearing the boundaries of the physical room. In addition, the creator can control and change the background of the environment with a variety of colours or personalized pictures. External observers can view the environment on a computer screen while artists are in the virtual environment, choosing either the creator's point of view or a fixed, external perspective.

According to film student Alice Krajcirova, who has worked on multiple virtual reality projects, "The viewer is now more or less the main character of the artpiece [sic] which seems to be a great tool for understanding that art and feelings contained in it." Furthermore, she believes virtual reality can facilitate experimentation and further the development of artists' work (Artfinder, 2021).

3. Virtual Reality Material

Since prehistoric times, human expression has been centred around art forms such as drawing and sculpting. In virtual reality, virtual environments are created by the combination of elements from painting (stroke, form, tone, 2D) and sculpting

(3D), as well as components made possible by the digital medium. Despite its similarities to the traditional mediums, this hybridity is a radically different form of expression (Hacmun et al., 2018).

According to cartoonist and Tilt Brush Artist-in-Residence Scott McCloud, "traditionally drawing was a way of *representing* 3D space. To draw *in* 3D space is a completely different challenge . . . the work circling you is something unusual" (Suppa, 2017). In contrast to traditional techniques like painting or sculpting, the materials in virtual reality are virtual. Creations made with virtual material are identical to paintings, except that the artist is able to create the artwork in three dimensions in a virtual environment. As a result, it allows users to observe the work from multiple angles as they might view a sculpture. Moreover, because the materials are virtual, it offers viewers the unique opportunity to walk through the artwork.

Such artistic mediums offer tremendous flexibility for artists to experiment and play around with their artwork. Artists can make changes or corrections to their artwork with actions such as erasing, undoing, and redoing. Experimentation and creation are crucial to the creative process, and this medium allows the artist to correct errors or make changes if necessary.

Artistic mediums can be created and saved in a variety of digital formats that allow them to be accessed and manipulated from almost any location or device. There is a system in place that allows for easy access to the material and a level of digital security when it comes to the material itself. Some artists like to save their work in a digital format so that they have access to it no matter where they are. They also enable many versions of the creative product to be made, each of which can then be saved.

This is as opposed to the physical product, which is lost once it is used for creation (Hacmun et al., 2018).

In virtual reality creations, a peculiar characteristic is that no limitations are imposed on expression by natural, physical laws. For instance, objects can appear to float in mid-air, apparently defying gravity. Moreover, this offers the capability to create elements with variable properties such as colour or location. Along with natural colours, the colour palette also contains a variety of textures and effects.

One of the most distinctive and revolutionary features of virtual reality art is the dynamic control of spatial dimensions. Canvas sizes are virtually boundless, and artists can scale and adjust dimensions throughout the creative process. Additionally, it is possible to add music, which influences the perception of various facets of the creative work. We can see that virtual reality develops traditional aspects of artistic creation, such as colour palette and brushes, while adding virtual reality–specific characteristics (Hacmun et al., 2018).

5.5. Exploration of Virtual Reality in Painting

Artist and researcher Tara Chittenden (2018) put forth that the emergence of virtual technologies would enable us to rethink conventional structures and materials in the discipline of painting, thus allowing us to reimagine paintings as a medium for exploring space.

Virtual reality is ideal for arts that are to be experienced, rather than merely viewed, due to its immersive and interactive qualities. The nature of virtual reality, however, requires a whole new way of thinking about the arts. As opposed to the traditional approach, which is to represent reality, art in virtual reality is about creating experiences that are unique to the medium. Bates (Bates, 1992) agreed that virtual

reality should draw inspiration from existing artistic forms and address more than just the user interface. In addition, the overall user experience should be taken into consideration when appreciating artistic virtual reality apps. Only when these conditions are fulfilled would virtual reality be able to realize its full artistic potential.

This means that when conceptualizing virtual reality art, an artist must consider the essence of virtual reality, and how this affects the process of creating and the artistic experience. With the novelty of virtual reality and its unique features, new forms of artwork could be created that utilize its distinctive capabilities. These characteristics should be taken into consideration when creating interfaces for virtual environments. Nonetheless, it is equally imperative to study the interfaces in established art forms. Combining this knowledge will enable artists to create better virtual reality artwork (Ramsier, 2019).

- **5.5.1. Experiencing Virtual Reality Art**

Virtual reality art can be explored in many ways, and there are many tools to assist artists in materializing their creative vision. Depending on their preferred process, they may choose to employ a specific app or platform. Using software like Google's Tilt Brush, artists can create whimsical paintings and sculpt in three dimensions. Complex objects can be created in 3D polygonal shapes using programmes such as Blender, and imported into 3D-modelling programmes like SketchUp and Maya to create fully immersive experiences. Furthermore, artists are also able to import pre-existing paintings, photos, animations, or even objects into the system in virtual reality–compatible formats (Artfinder, 2021). This opens the door to creative expression and experimentation that could not have been explored in any other way. Not only that, but artists are also able to share their virtual reality art with

the world through the internet, in a way that is impossible to do with traditional 2D canvases.

Online virtual reality "worlds", or platforms, such as Somnium Space, are bringing art lovers and artists from all over the world together, even those who may never get to physically meet. According to Artur Sychov, Somnium Space's founder and CEO, his organization is working on projects that revolve around virtual reality, including one that will let artists set up galleries within minutes. Sychov claims that increased accessibility will potentially change art, as he believes that his open-source platform "will allow a completely new set of people and artists to finally have tools everywhere they go and start creating anything they would want to create anywhere they would want to" (Artfinder, 2021).

Artist Hana Auerova described Sychov's innovation as offering a new way of experiencing "total artwork," that is, "an artwork one can spend his lifetime in and never walk out [of]." The experience "will be like having your own private art gallery at your fingertips," which one can choose to keep private if wanted. Auerova continued, "You can experience everything in 360 degrees around you, the floor and sky included, you can . . . see [the artwork] from different angles . . . use your haptic and other senses" (Artfinder, 2021).

In terms of its virtual reality's application in art galleries and museums, what made an impression on artists was the way it can serve as a platform to host a variety of installations. Aritst Jorge Rodriguez-Gerada remarked, "What really struck me was the ability that this has for this to be a platform for installations in museum and gallery space." Graffiti artist Chu (2018) agreed, stating that a virtual reality app such as Tilt Brush "is going to revolutionize how people are going to view immersive artworks."

These sentiments emphasized the potential of the technology as a platform for installations in museums and galleries (CNN, 2016).

A number of organizations are actively recognizing virtual reality art around the world. One instance is Lumen Art Projects, a not-for-profit social enterprise that showcases and celebrates art that has created with the use of digital technology. Charlotte Lee, assistant director of The Lumen Prize, which Lumen Art Projects runs, said in 2016 that artists are showing an interest in virtual reality globally, which has a potential to start transforming the art scene. Lee commented, "We saw virtual reality receive a big thumbs up from the art world . . . more so than any other medium, VR has the potential to transform how we, as voyeurs, look at art." She continued, "This technology questions the boundary that exists between the real and the virtual, but it also has the ability to break down the barrier that exists between the spectator and the work of art" (Fearn, 2016).

According to Lee, when someone has worn a virtual reality device, they will be taken to another dimension, creating an experience that incites different emotions. No longer is artwork just something to view at a gallery or museum, instead, it is something people can explore as well as participate in (Fearn, 2016).

- **5.5.2. Virtual Reality Painting Application**

Several digital technologies, such as virtual reality, are transforming artistic and design practices. As virtual reality devices become more prevalent, artists are utilizing virtual reality for a wide array of artistic endeavours. In addition to painting and drawing, artists are also using virtual reality for 3D modelling and sculpting, animation, and more (Breia, 2021).

Virtual reality has the advantage of allowing artists to express themselves creatively. They are able to experiment with colours, tools, and an infinite canvas. The virtual environment can be designed according to their specifications, and they can navigate it in any way they like. For example, they can walk through the artwork and experience it. The use of 3D space for control and navigation can feel more natural to artists than clicking on a computer (MOR, 2020).

The exciting potential of this new medium has led to the creation of various apps and tools to allow users to paint, sculpt, model, and animate in virtual reality. Several tools are being developed for artists to take advantage of virtual reality (Breia, 2021).

- **5.5.3. Virtual Reality Painting Application – Google's Tilt Brush**

In this section, I will examine and focus on Tilt Brush so as to assist my research. Tilt Brush is one of the most widely used virtual reality painting apps, which has great potential for future development both for developers and artists. The app enables new opportunities for art creation and creative industries.

There are a variety of tools and software available that are designed to facilitate the creation of art in virtual reality. These look to replace the physical paintbrush. A great example is Google's Tilt Brush, originally designed for the HTC Vive. It is one of the most popular virtual reality sets for the visual arts (Artfinder, 2021). In terms of art and painting, Tilt Brush transforms the headset's controller into a paintbrush and palette, and the surroundings become a canvas for artists to paint on. Using Tilt Brush, users can experience both traditional and new forms of art.

With over 22 years of experience as a digital artist, Simon Fenton (2016), also the head of games at Eclipse Studio, confirmed that technologies like Tilt Brush

enhance creativity and open up new possibilities. He pointed out that the development of technology such as Tilt Brush "has the potential to break down the barriers of art" (Fearn, 2016). The concept of this new space combines sculpture, painting, architecture, design, and games all at once, allowing users to immerse themselves in art and build their artwork around it. With no physical limitations, art can now be created and viewed from a greater range of varying perspectives.

- **5.5.4. Artistic Potential of Google's Tilt Brush**

In 2015, Google acquired developer Skillmen & Hacket in order to obtain Tilt Brush. The app was then released in February 2017 for HTC Vive, later expanding to be compatible with other platforms such as Oculus Quest and Rift, Windows Mixed Reality, PlayStation VR, and Valve Index (Chittenden, 2018). Upon its official launch in April 2016, Tilt Brush has been widely marketed as an introductory app for virtual reality experiences (Ungerleider, 2016) and hailed as "set to revolutionize the definition of painting and push the boundaries of what it can represent" (CNN, 2016).

Tilt Brush offers a painting environment, a range of brush options, an intuitive interface, and customizability. Artists can use Tilt Brush to create their art and be immersed in it. Tilt Brush is "intuitive enough to allow anyone to create immersive 3D artwork, and both the artist creating the piece and the viewers admiring it" (Avila & Bailey, 2016).

Figure 3: Google Tilt Brush Brushes

Virtual painting in Tilt Brush involves the artist being directly connected to the space and the substance of the painting through the virtual reality headset. These are inseparable elements that constitute a continuum between the viewing space and the artist's point of gaze. When a user gets too close to a wall or an obstacle, a chaperone system maps the surrounding physical space in the user's vision.

Tilt Brush is similar to most digital painting apps that support the creation of artworks. Users need to have a headset, handheld controllers, and tracking beacons for accurate tracing patterns in 3D space. There are three main tool areas in Tilt Brush: File Tools, Colours, and Brushes. Users using the virtual handheld palette can change the environment and select different types of brushes and effects.

Artists in Tilt Brush create art in a virtual environment, a 3D virtual space, allowing them to have artistic capabilities and freedoms that are impossible to achieve with traditional methods. In comparison, artists who use traditional mediums such as crayons, pencils, and paints have less space or fewer options to express themselves fully on 2D spaces such as paper or canvas (Schaaf, 2019).

Virtual reality painting apps offer significant ways of making the artistic process easier. Its rapid development lets artists create new content, broaden the creative space, and create new art forms, thus augmenting the traditional means of artistic expression. It has also transformed the creative experience by creating a 3D virtual space that helps make the process more intuitive and natural as compared to painting in two dimensions.

A completely new aesthetic experience can be established in contemporary painting within the context of this new technology and its application, rethinking

painting in terms of gesture, material, process, and its relationship with tangible and virtual spaces. If someone is looking at a virtual reality painting in a physical or virtual gallery space, they are going to be able to walk through, rotate, and act on it (Chittenden, 2018).

In virtual reality, artists can create entirely new imaginaries, which are highly appealing to creative people, and also a whole new vocabulary. Like artist Hana Auerova said, "You'll find new possibilities for the artist, and for the audience that often interacts with the environment, and for the communication [between them]." (Artfinder, 2021).

- **5.5.5. Open-Source Tilt Brush**

Since its launch in 2016, Tilt Brush has firmly established itself as one of the definitive virtual reality apps. Tilt Brush has attracted artists from around the world to create stunning artworks. Nonetheless, Tilt Brush cocreator Patrick Hackett left Google in January 2021 and joined I-Illusions, a virtual reality games studio (Lang, 2021). Following that, Google revealed that Tilt Brush is no longer being actively developed, much to the disappointment of those involved in virtual reality art. In response to Google's decision, Hackett said, "To some, this may appear like the end of Tilt Brush, but to me, this is immortality." By making this move, everyone would have the opportunity to understand how Google constructed the project and also have the freedom to explore directions that hold personal significance to them (Hayden, 2021).

In their official statement, Tim Aidley and Jon Corralejo, respectively software engineer and program manager for Tilt Brush, remarked that "as we continue to build helpful and immersive AR experiences, we want to continue supporting the artists using *Tilt Brush* by putting it in your hands." Following this announcement, Tilt

Brush's development and future support will be left to the community (Melnick, 2021).

In response, artists and enthusiasts expressed relief and continued creating works on the platform. Max Weisel, a researcher whose company was acquired by Google, credited Tilt Brush with shaping so much of the virtual reality ecosystem. The decision to open source the tool, to him, was a gift to the community. "I hope this means it will live on forever," Max Weisel tweeted (BBC, 2021).

Upon learning that Google had decided to make Tilt Brush open-source, the virtual reality community responded by experimenting with the code and seemingly accomplishing what Google couldn't do. Tom Neumann, cofounder and chief technology officer of Rendever, instantly developed a multiplayer version of Tilt Brush, a feature long requested by its users. A real-time collaboration feature, via Rendever's free Multibrush app, allows users to sign into the same room and work side by side on 3D artwork (Jagneaux, 2021).

Rendever has made a lot of progress in such a short period since the open-source code went live, especially considering how long Google took to develop a multiplayer function. According to Rendever, the multiplayer function makes physical distance less of an obstacle to social connections (ILN, 2021).

- **5.5.6. Virtual Reality Painting Application – Other**

Virtual reality app Tilt Brush gives pencils and brushes new versatility and levels of creativity. In addition to changing colours and drawing in the air, artists may alter textures, scale, push, pull, undo, select strokes, and replicate them easily. Aside from Tilt Brush, there are a variety of virtual reality apps for creating artworks in

virtual reality, ranging from sculpting to animation. As a result, these apps expand what it means to create unique works of art on a virtual canvas.

1. Facebook Quill

As an extension of Oculus Story Studio, Quill was originally designed to meet the creative needs of author and director Saschka Unseld and art director Wesley Allsbrook on an illustration film. The short film, "Dear Angelica" (2017), was the first VR-enhanced animated experience to screen at the Sundance Film Festival (Harris, 2018).

In Quill, the artist can paint on a blank canvas with a similar degree of creativity and artistic expression to what they can do with Tilt Brush, though they can scale that canvas to a much greater extent. There are a variety of styles and options offered by Quill, including watercolour, pencil, oil painting, and comic. With the touch controls, artists can experiment with brush shapes and strokes to a relatively precise amount of pressure (Harris, 2018). As stated in a Facebook blog post, "Quill animation brings a new level of freedom to artists in this rapidly emerging medium" (Matney, 2018).

As a unique feature, Facebook's Quill allows for quick 3D illustration and animation, giving users the ability to create immersive storytelling experiences. Additionally, it can be used for pre-visualization, concept design, storyboarding, and set design (Quill, 2022).

In 2021, Oculus no longer support Quill, and creators will not be able to upload their work directly to Oculus Media Studio. This raised concerns about the longevity of technology-based artwork (Holt, 2021).

2. Medium by Oculus

Oculus, a Facebook-owned company, created Medium and launched it on Oculus in 2016. One limitation is that the app is tightly integrated with the Oculus Rift, so it is only available on that device. With Oculus Touch controllers, users can create objects in a virtual reality environment for painting, sculpting, modelling, and creating (Bitner, 2018).

A variety of tools can be used to sculpt and paint clay in Medium. It offers hundreds of prefabricated stamps that can build complex structures, then export high-quality meshes for 3D modelling and printing. With its multiuser capabilities, artists can even collaborate with others. In addition, Oculus hosts a community site where artists can save and share their work (Bitner, 2018). Medium offers helpful tutorials and guidelines for those new to painting apps, even if it may seem intimidating at first. For this reason, Oculus encourages beginners to try Medium (S3Art, 2021).

It was announced in 2019 that Adobe had acquired Medium. Medium 2.0, its latest update, appeals primarily to experienced painters, offering features such as grid snapping and multiple lights. Additionally, Medium's tools, settings, and options have been made more intuitive so artists can spend more time on creative flow and ideation (Harris, 2018).

3. MasterpieceVR

MasterpieceVR, now called Masterpiece Studio, was another painting or sculpting app released in 2017. There are two products that are included in Masterpiece Studio: Masterpiece Creator and Masterpiece Motion. Masterpiece Creator allows artists to emulate sculpting with virtual tools that blend traditional 3D-

creation capabilities, volume sculpting, and brush painting; while Masterpiece Motion is specifically geared towards modelling and animation (Bitner, 2018).

Masterpiece Studio is cross-functional in that it can help do painting, sketching, and volumetric sculpting, with brush strokes. It combines the features of both Tilt Brush and Medium. The software allows the artist to create tangible objects, colourful environments, and high-quality models. Additionally, it is a multiuser platform that allows up to four users to collaborate and 20 viewers to view (Bitner, 2018).

A new virtual reality, 3D creative suite called Masterpiece Studio Pro was released in 2021, enabling creative professionals without 3D-modelling experience to create 3D content. A program like Masterpiece Studio Pro enables artists to create things they would not have been able to. According to Dylan Sisson, digital artist at Pixar Animation Studios, “Just by being able to take my 2D skillset, directly apply it in 3D, and then take those 3D assets to do something like 3D print is such a fluid and immediate process” (Auganix, 2021).

Jonathan Gagne, CEO of Masterpiece Studio, believes that virtual reality can revolutionize 3D content creation by accelerating, simplifying, and enhancing the creative process (Auganix, 2021).

- **5.5.7. Summary of Virtual Reality Painting Application**

The above is not an exhaustive list of virtual reality painting tools; they are just some of the most well-known. Some apps have limitations, and part of that is due to the fact that virtual reality is still a new medium that has plenty of potential.

The introduction of Google's much-hyped Tilt Brush and other virtual reality painting apps has paved the way for creating virtual reality art. Painting, drawing, sculpture, and 3D modelling are all new again, but this time the virtual world is in three dimensions and not just on a computer screen. These tools prove that virtual reality is more than just a form of entertainment—it is also a tool for productivity. It is becoming the tool of choice for a variety of artists, whether traditional or digital (Bitner, 2018).

In summary, art has always been associated with innovation and modernity. It is also intimately related to a need to avoid conventionality and push the boundaries of what is possible. Due to this, virtual reality can play a pivotal role in the search for new forms. Artists will have "new ways of expressing themselves and creating unimaginable forms of art" with the development of more advanced tools for artmaking in the coming years (Breia, 2021).

- **5.5.8. The Challenges of Virtual Reality Applications**

It is fascinating to observe how virtual reality is being adopted and integrated in the early stages. New tools, techniques, and apps are constantly appearing and advancing, but for this technology to be practical, they need to be functional and able to meet the needs of artists who use them (Ramsier, 2019). There are several challenges that virtual reality faces at the moment, which will be discussed in the following section.

1. Motion Sickness

Virtual reality's impact on the creative process, and ability to create a more immersive experience, is receiving a lot of attention. One of the biggest challenges with virtual reality has been that the need to wear the virtual reality headset at all

times, in order to feel as if one is in a virtual space. While such systems offer exciting new experiences, they also come with their own set of health and safety concerns, most notably over long-term use.

Since their introduction, virtual reality systems have been known to cause motion sickness as a side effect. There are a number of symptoms, like eye fatigue, nausea, and disorientation, that can negatively impact users' virtual reality experiences (Chang, Kim, & Yoo, 2020). These side effects are thought to be caused by the way in which virtual reality systems trick the brain into believing it is moving when it is actually stationary. Motion sickness caused through virtual reality systems has been a critical issue as virtual reality has become a widely distributed technology (Chattha et al., 2020).

Similarly, digital artist Simon Fenton pointed out, "This medium invites us to engage at a very different level but it has its own issues such as motion sickness, and for people like me with glasses it can be a real pain" (Fearn, 2016). The inconvenience and fatigue of wearing virtual reality headsets make it difficult for people to fully explore its possibilities, as they cannot create artwork for long durations. In the future, we may see advancements in the design of virtual reality headsets, allowing users to wear them for long periods of time. Such a solution could lead to a broader adoption of virtual reality systems.

2. Technological Change

Virtual reality represents a new artistic revolution. The advancement in technology that we see today is just the beginning. It is, however, impossible to predict whether a new system will be compatible with the current one, which may cause an artist's artwork to become inaccessible. The Lumen Prize assistant director Charlotte

Lee put forth that for the art industry to be technologically advanced, it must be backward compatible. She acknowledged that it will be a challenge that the entire art industry will have to deal with in the years ahead. She continued, "The main concern around these works is their longevity. Technology is advancing at such a rapid rate that if these works aren't updated or migrated then parts of our culture will be lost forever, and sadly some of it already has been" (Fearn, 2016).

At the moment, institutions like Rhizome, which celebrates digital art, are actively working to preserve the accessibility of technologically engaged works for future generations. However, related expenses are enormous, and one needs to consider whether a piece of artwork will be the same when it is executed on another system. It is believed that technologically driven works will die as soon as the technology is no longer able to support them. Digital art, including virtual reality, may face this issue. As technology rapidly advances, the only way to ensure these works are not obliterated is to use new technology that is compatible with the old. While there are questions about the longevity of this technology, experts believe that it will only improve (Fearn, 2016).

3. Materiality

Painting has long been a means of exploring the surface of things. Moving through a painting's pictorial space allows us to explore the painting as more than just a flat 2D surface. As artist-researcher Tara Chittenden (Chittenden, 2018) put it:

> An issue for painting becomes the ability to move within pictorial space in ways that expand and thicken conceptions of surface. These VR paintings invoke questions of materiality, the painting as object-vs-image and as 'hypersurface' where distinctions between structure and surface collapse.

This quality is not possible in traditional mediums like oil or watercolour, but it is in virtual reality, where we can move around in 3D space. Paintings in virtual reality thus bring with them questions of materiality, the painting as object, and our relationship to it.

Paintings are defined by their pigments and materiality; the surface is the physical foundation on which we perceive colour, form, and space. In virtual reality, the virtual world is defined by our presence in it. Everything we see in virtual reality is generated by our experiences, actions, and interactions. Therefore, the surface of a virtual reality painting is not just determined by the materials used but also by our actions in the virtual space.

Chittenden's concerns about the implications of virtual reality apps for contemporary painting practice evolve around challenging the concept of a conventional frame of a painting, posing questions regarding the nature of boundaries in artistic practice. Virtual reality works can be accessed anywhere through headsets and virtual reality files, yet they appear within a surrounding that is not physically related to the viewer personally (Chittenden, 2018).

There is an opportunity for contemporary painting, however, to create a new aesthetic experience that is unique to this point in time and culture; this involves a process of rethinking painting in terms of gesture, material, and process, as well as the painting's relationship with our physical and virtual worlds. Ascott (1999) suggested that the transformative art of the new century will be concerned with the construction of fluid reality. He calls for artists, as well as philosophers and neuroscientists, to pay more attention to what he calls "technoqualia," a "whole new repertoire of senses," and a new kind of relationship between the means of seeing and building (Ascott,

1999). People can be creative with virtual reality painting tools, such as Tilt Brush, in a variety of different manners. In doing so, artists will extend the painting practice and art theory with VR-augmented ways of seeing (Chittenden, 2018).

Some may argue that traditional art does not have a place for technology. But virtual reality has shown that technology has the potential to be used by artists in many ways, such as applying virtual painting techniques or showcasing work digitally. Despite some deeming virtual reality technology and its painting application to be in its early stages, several artists and creators are already revolutionizing the industry.

6. RESEARCH METHODOLOGY

This dissertation uses qualitative research methodology comprising of literature analysis and a comparative study among selected virtual reality artists and their artworks, thus providing deeper analysis.

The research design for this study takes a systematic and structured approach, ensuring clarity and consistency throughout the research process. When choosing the participants for the interviews, thorough evaluations were conducted to secure a diverse and representative sample of virtual reality artists.

As part of the interviewee selection process, several criteria were considered, including the interviewee's skill and experience in using virtual reality as a creative medium, the originality and creativity of their work, and their contributions to the field. By choosing artists with various artistic styles, backgrounds, and expertise levels, the research aims to capture a representative, wide-ranging portrait on the use of virtual reality technology for artistic purposes.

The flow of the study comprises three primary stages. First, comprehensive literature review is performed to establish a foundation of knowledge and understanding of the existing discourse on virtual reality art. The purpose of this analysis is to identify key concepts, theories, and trends in the field, which will facilitate the subsequent phases of the project.

The second part of the study involves a comparative study among a selected group of virtual reality creators and their artistic creations. This approach allows for a deeper analysis of the artists' practices, techniques, and creative processes within the virtual reality medium. Through an analysis of the commonalities and disparities in their artistic creations, the research aims to reach an understanding of the capability of virtual reality as an artistic medium.

During the third stage, in-depth interviews will be conducted with the selected artists. The interviews will have a semi-structured format, offering flexibility while making sure that key research questions are covered. The purpose of the interviews is to collect opinions and first-hand information from the artists, and explore the artists' motivations, challenges, experiences, and reflections on using virtual reality for their artistic endeavours. By delving into their artistic processes, perspectives, and the challenges they faced, the study seeks to provide a comprehensive understanding of virtual reality art.

This study also includes participatory research involving artists who have no prior experience with creating artwork using virtual reality tools. This experimental approach offers an opportunity to evaluate their experiences and artistic processes, providing a valuable perspective on the learning curve and challenges faced by newcomers. The inclusion of interviews in this participatory research section allows

for a critical and holistic examination of the non-VR artists' first use of virtual reality technology.

As a primary app, Tilt Brush is utilized for virtual reality painting in this study. Choosing Tilt Brush for our research is important due to its market dominance, unique features and engaged user base. In comparison to other virtual reality painting apps, Tilt Brush is widely used by artists, particularly new users, making it a suitable choice for this research. Google has also developed Tile Brush over the years in collaboration with a variety of artists, some of whom were part of their Artist-in-Residence programme. Additionally, Tilt Brush's open-source status means I will also be able to study the technical challenges the app will face and the impact it will have on artists. Through a thorough consideration of these factors, Tilt Brush was the natural selection as the main tool of analysis, ensuring the validity and relevance of the research findings.

6.1. Professional Virtual Reality Artists and Their Artworks

Artists have long been the pioneers of the digital realm, pushing technological and critical potentials to their limits. Through technological advancements, it has been observed that artists, working with various forms of mediums, have begun to use digital technology such as virtual reality to produce different aspects of their artworks.

Additionally, Tilt Brush's release has led to the development of mastery among artists who have been producing work within virtual reality for years. The following section presents renowned artists who work with virtual reality app Tilt Brush, and their selected artworks.

- **6.1.1. Artist - Sabrina (The Sabby Life)**

Sabrina is an artist who started out painting on canvas and transitioned to virtual reality. She experimented by painting in a virtual environment and now transforms traditional painting into a virtual reality experience. According to Sabrina, virtual reality art differs greatly from traditional art in that one has unlimited supplies and no space limitations with virtual reality (Mileva, 2021).

It all began during her research on how to achieve a 3D effect in her paintings. Sabrina came across an advertisement for Tilt Brush, which led her to explore painting with the then new virtual reality art medium. As she shared:

> "I am quite an explorer—very inquisitive, usually able to figure things out on my own . . . When I first tried using Tilt Brush, I realized that I could use my traditional digital 3D art skills to work this medium. It's such a new medium that everything felt like a discovery. So, I figured that I would have to start experimenting" (Muzaffar, 2020).

Furthermore, after noticing many questions raised on the use of Tilt Brush as a virtual reality creation app, she created a Twitch live stream where she asked her audience for feedback.

Her repertoire has since grown to include the use of apps such as MasterpieceVR, Gravity Sketch, and Tvori, which are virtual reality tools for sculpting, designing, and animation. Her art serves as a means of visual storytelling, allowing her to convey a behind-the-scenes perspective that adds depth to the narrative. (Mileva, 2021).

Her artworks are significant to this study as she has utilized a wide array of virtual reality software and developed a specific and unique style. As technology is constantly growing and evolving, she dismissed the concept of styles in virtual reality as a "fleeting and transitory notion." She believes that "the ideas can still be the same, but the style adapts itself to changing tools" (Powell, 2018).

1. Early Virtual Reality Experiments

The first virtual reality headset that Sabrina used was Google Cardboard. However, the HTC Vive, has been her favourite headset. Besides Tilt Brush, she has combined the use of several virtual reality apps, including Gravity Sketch, AnimVR, MasterpieceVR, Neos VR, Logics, and Mindshow, in the building of her virtual persona. She was first introduced to VR art by a YouTube commercial for Google's Tilt Brush. During her exploration of Tilt Brush, she applied her knowledge of anatomy and colour theory to improve her spatial skills (Mileva, 2021) .

Sabrina's first experiments with virtual reality art were largely based on "trial and error." In her creative process, decisions on what kind of art were not always made instantaneously. She mentioned, "I would start with an idea, or even just a feeling. I'd try to imagine what I want to create. Sometimes I'd sketch it out and other times I just jump right in and start creating it in Gravity Sketch or Tilt Brush" (Muzaffar, 2020). These apps has allowed her to explore a plethora of ways to express herself, and to think and reconsider her approach to her work. The ability to reflect and rethink, over time, has been invaluable in helping her to improve and develop as an artist in coming up with something unique.

Sabrina's "365 Days of Tilt Brush" project has made her workflow heavily dependent on Tilt Brush. Throughout the experimentation project, she strived to

understand the nuances of each tool, so that with every experience, she was a step closer to understanding the medium. Using all the brushes at her disposal has helped her push herself to her limits and to figure out the direction in which she wants to go. In addition, by having a weekly theme to draw inspiration from, she had new things to create every week and a chance to consistently practise her art (Muzaffar, 2020).

2. Virtual Reality Community

In order to engage the virtual reality community, Sabrina spends some of her time answering questions and replying to direct messages on her social media, such as YouTube and Twitch. The majority of these enquiries ask, "How did you do that?" In response, she began making tutorials for her followers, and her supporters usually respond to something they like in her work (Muzaffar, 2020).

In a world driven by the internet, Sabrina shares why being seen is important: "Early in any public-facing journey, it's hard to know what having followers could do for your craft . . . an audience has not simply been garnered for engagement but also for curbing curiosity" (Muzaffar, 2020). At times, Sabrina's followers would encourage her to attempt experimenting with different things. Through this, she gets a better sense of her practice, as well as other possibilities and opportunities of creating that might be available to her. In addition, on Sabrina's Twitch channel, an interactive community was created for her viewers to learn about each other and create stories. Sabrina also engaged with other MasterpieceVR artists in the same VR studio room to create a collaborative art piece (Powell, 2018).

Furthermore, Sabrina and her team are developing the VRArtLive Community; together they collaborate to curate events, exhibitions, and talks. Through all their

activities, the VRArtLive team strives to remain approachable to anyone interested in virtual reality (Muzaffar, 2020).

In essence, the community is made up of a group of artists who are most willing to share, and they stress the importance of learning from one another and growing together. By fostering long-term projects, conversation threads, and resource pools, this community is capable of supporting one another and encouraging the development of virtual reality art. Sabrina recognizes the importance of exploring immersive technology, noting that it can be useful in bridging "a lot of communication gaps between the worldwide family of people" (Mileva, 2021).

3. Artwork - Da Vinci Paints the Mona Lisa, 2018

Sabrina is best known for the immersive painting *Da Vinci Paints the Mona Lisa* which is inspired by the work of Leonardo da Vinci. It is a virtual reality installation created using a combination of painting and sculpting fundamentals from Tilt Brush (Sabrina, 2020). Taking her over three months to complete, this early art piece of hers is significant in laying the foundation for her future work.

Figure 4: Sabrina (The Sabby Life): *Da Vinci Paints the Mona Lisa*, 2018

Inspiration - The idea behind her recreation of the *Mona Lisa* painting was to highlight a behind-the-scenes look of da Vinci's work. She further explains:

> "I wondered how many people think about Da Vinci actually painting the Mona Lisa. I wondered what he was imagining as he captured Lisa del Giocondo's image on the canvas. I think he already knew what the background would be for her portrait. I love to show the hidden activities beyond what is actually seen."

According to Sabrina, this can reveal something that seems "mysterious and unreachable" to be something achievable. The same concept motivated her to stream live and share ideas with her followers (Powell, 2018).

Creative Processes - It began with a 2D *Mona Lisa* portrait, then a 3D version of da Vinci painting the portrait of Lisa del Giocondo, and finally an environment that depicts da Vinci's imagination as he worked on the painting.

Intending to depict da Vinci painting the *Mona Lisa*, Sabrina designed the layout as if it were an installation art piece. Then, using reference photos to study the portraits of Lisa del Giocondo and Leonardo de Vinci, she envisioned their body shapes and sizes.

In order to capture the proportions and outlines in each plane, she first sketched from all angles. Once the basic wireframe was established, she was able to go into 3D by adding fine contour lines to define the shapes. She elaborates:

> "I started with a basic sketch to capture the proportions and outlines in each plane—the sagittal, coronal, and transverse—as if it were a drawing from every angle. Once this sort of wire frame existed, I was able to start adding fine contour lines to define the 3D shapes as if I were sculpting".

Sabrina then painted the frame with brush strokes like papier mâché strips, so they would not blend, defining each 3D shape as if she were sculpting.

Following that, she set the light source in Tilt Brush to mimic the lighting in the reference photo of the *Mona Lisa*, and finally painted the shadows to finish the piece. Which is to say, she worked first on the shape and volume of her subject, followed by shadows and colour (Powell, 2018).

Sabrina acknowledges that virtual reality art has incredible potential for interactive experiences, and that people want to have these experiences because it lets them express themselves more freely. Rather than being an observer, the viewer would feel like they are a part of the story. "The message I got from the experience was, *Let's make a story together*, which gets people involved and makes you feel good to see your ideas being used", she remarked. Sabrina is looking forward to seeing multiplayer functionality in virtual reality art software, to allow artists to socialize more and for more audiences to see works from different perspectives (Powell, 2018).

4. Artistic Style

The process of creating Sabrina's virtual reality artworks involves a combination of painting and sculpting fundamentals. While her works resemble 3D digital art and sculpting because she takes into account all viewing angles, her method of making the art piece is similar to traditional art, with hand movements.

As with any other artistic medium, familiarizing oneself to its strengths and limitations is essential. According to Sabrina, technology has changed her process from traditional art methods to virtual reality. There are various ways of executing the artwork since it is digital. Things can move around at will, and layers can be added

depending on the app used. Moreover, in contrast to a traditional medium, the digital form is not constrained by "chemical processes." She has some concerns, however, with this new medium. As she points out, "There are unique issues that come along with it, like glitches or file load considerations, and things of a digital nature."

For Sabrina, the flexibility of being able to create anything she wants with virtual reality art is truly liberating. It is a capability that is technically infeasible with traditional art mediums. She concludes, "Because of this technology, in my mind, my art pieces have no limits compared to traditional canvases" (Powell, 2018).

The knowledge Sabrina gained from traditional art proved beneficial when she uses virtual reality art tools for painting. Styles, though, do change. Sabrina adds, "It's going to be different in each medium, right? The ideas can still be the same, but the style adapts itself to changing tools" (Muzaffar, 2020).

Sabrina was able to develop a distinct flair that has been aptly called "stained glass style" by her followers. She developed this with Tilt Brush across multiple pieces that she shared on the internet. As the tools continue to be updated and improved, Sabrina hopes people who use virtual reality will improve their skills. As an artist, she prioritizes experimentation, restyling, and constant development of her skills. Likewise, she believes that her own style is continually changing as there is plenty of room for experimentation with the number of different brushes available, as well as the introduction of new apps. Appreciating that there are quite a number of virtual reality artists, Sabrina believes that every one of them is discovering and developing their own distinct form. In the same way Sabrina was drawn to Tilt Brush as a painter, she believes that other artists with experience in other mediums will eventually find the style they are looking for.

As a way to make a successful transition to virtual reality, Sabrina advises interested individuals to conduct their research and experiment and stay committed. In the future, virtual reality has the potential to affect every aspect of life, and creators should be a part of it, she believes (Muzaffar, 2020).

- **6.1.2. Artist - Tamiko Thiel**

Tamiko Thiel is a visual artist who is internationally well-known for exploring social and cultural issues in VR art. She is one of the pioneering artists that uses virtual reality technology for her artworks, and was selected for the Google Artist-in-Residence programme. It is a programme that introduces artists from different backgrounds and helps them explore their individual styles and possibilities using virtual reality as a medium. Thiel has worked with a Google team to develop the tool Tilt Brush and researched the potential of this new form of art creation (Thiel, 2021). Examining how Thiel works and develops with virtual reality would lead to a better understanding of the art-making process in tandem with technology.

Her virtual reality and augmented reality works are featured in books such as *Digital Art* (2003) by curator Christiane Paul, which I refer to in my literature review.

1. Early Virtual Reality Experiments

In 1994, Tamiko Thiel was specializing in video art as her form of artistic practice. Her then profession was a producer and creative director at a company that was doing virtual reality in Virtual Reality Modeling Language (VRML) on the internet. Having done several projects, Thiel realized she wanted to work with multiple screens in an encircling installation.

Through Thiel's exploration of VRML, she has made three different pieces using immersive environments, a kind of artwork involving the creation of complex 3D worlds within the form of a more traditional screen projection.

The most notable piece was *Beyond Manzanar* (2000), based on the actual location of Manzanar, in California, one of the more than 10 internment camps built during World War II to incarcerate Japanese Americans. The project was cocreated with Zara Houshmand. In *Beyond Manzanar*, viewers kinaesthetically interact with the virtual environment of the Manzanar War Relocation Center by using unique, spatial characteristics of navigable 3D virtual reality. As part of the experience, a large image of the 3D space is projected on to a wall in a darkened room, and viewers change their view using a joystick.

When the dominant video system was VHS (Video Home System) in the mid-90s, the image quality was bad and expensive to produce. Every single screen needed its own VHS tape deck, and every single screen had to be a Cathode-Ray Tube (CRT) monitor. Projectors were even more expensive then. Tamiko Thiel reveals, "I was a young artist, and I did not have the money; therefore, no one was interested in giving me a lot of money or a lot of equipment" (Thiel, personal communication, January 31, 2021). Consequently, she began working with virtual reality when she wanted to work on video art, since it was easier in virtual reality than having to purchase a lot of equipment. In this regard, virtual reality allowed Thiel to explore the spatial dimensions of art, which is why she became a visual virtual artist in the first place.

2. Google's Tilt Brush Artist-in-Residence Programme

In the early 2000s, no one was interested in virtual reality. Nonetheless, with the advent of the Oculus Rift in 2016, a surge of interest in virtual reality arose as it

became possible to use VR in an entirely different way. Google launched its Artist-in-Residence programme in 2017 to show its commitment to this burgeoning and rapidly evolving new artistic form.

The initiative introduces more than 60 artists to virtual reality through Tilt Brush, while demonstrating how it can be used to further their creativity. Many of these artists come from diverse backgrounds and disciplines; some are emerging or experimental, others are established or traditional, but everyone has their unique style. Thiel eventually joined Google's Tilt Brush group, which was her first experience with Tilt Brush.

Using Tilt Brush for the first time reminded her of what she wanted back in 1985, when she first became an art student. She recalls:

> "I suddenly remembered that I was like in the beginning days of my time as an art student . . . I wish I could paint and do ink brush painting in three dimensions as I can with calligraphy or ink brush painting on paper."

According to Thiel, the problem with Tilt Brush is that when she first tried it, she also wanted movement and sounds, but the app did not develop in that direction despite its spatial nature. Since she envisioned Tilt Brush to progress, she used her Google residency in San Francisco to work with them on adding 3D spatial sound to the Tilt Brush environments. Eventually, the Tilt Brush group made a Unity plug-in for Tilt Brush, allowing the artist to draw a scene with Tilt Brush, import it into Unity, and add 3D spatial sound. Thiel ended up composing *Land of Cloud* in that manner.

3. Artwork - Land of Cloud, 2018

Land of Cloud was the first installation Tamiko Thiel completed with the Tilt Brush app. She also made use of the Unity tool kit in Tilt Brush to import the sketch into Unity 3D, where she added 3D spatial sound. *Land of Cloud* is a virtual reality and 3D sound installation created with a "unique brush, texture and calligraphic gestural stroke that determines its form, appearance and composition" (Thiel, 2021).

As one enters the *Land of Cloud*, one hears a sound like "a susurration of voices . . . Plac[ing] your head inside the head of a cloud person, walking up to them, sitting or lying down next to them, you will hear that each one repeats its own mantra, given by the Cloud Deity" (Thiel, 2021).

Figure 7: Tamiko Thiel, *Land of Cloud*, 2017

Inspiration - It came from the time when people were talking a lot about cloud computing and moving data there for computing needs. On top of that, nowadays, people use their smartphones all the time, and one would see people walking around with them in their hands. People's faces light up at night because they are looking at their smartphones, making them seem like ghosts. With the cloud component coming in, it was also the idea that these people are in this beautiful garden, but they are isolated and not speaking to each other.

In the Land of Cloud, there is a beautiful garden, and yet the Cloud People seem oblivious to its beauty. They stare intently at their devices, motionless,

spellbound by the whispers of The Cloud. Slowly, the garden envelops them in its boughs as it slowly engulfs the Cloud People.

Creative Processes - To Thiel, *Land of Cloud* was about experimenting with gestures and exploring what she could come up with within Tilt Brush. Similar to painting, the act of creating in Tilt Brush to Thiel is an "immersive, gestural experience in which not just the hand, or arm, but the full body is the brush" (Thiel, n.d., Making of Land of Cloud section, para. 1).

Thiel began by creating the garden with all its different plants. To convey the distinctiveness, each plant in *Land of Cloud* is shaped and composed by its own exclusive combination of brushstroke, texture, and calligraphic, gestural stroke. She then considered what would be the right gesture for the human figures. She experimented with drawing skeletons in 3D form and sculpting external human forms. These human figures were created using "softly billowing clouds that coalesce into constantly shifting bodies" (Thiel, n.d., Making of Land of Cloud section, para. 1). There are also some brushstrokes on the Cloud People's faces, such as on their eyebrows, eyes, noses, and mouths.

Thiel, however, realized that having a static 3D scene is a contradiction. She wanted her installation to be four-dimensional (4D). Thus, she included audio and made it an interactive piece where the audience would need to go around to each figure and interact with them. She describes the intention and experience:

> "The whole point of the space is that you hear all this whispering when you come in. You cannot understand what they are saying until you go to each one, and you have to put your head inside the head of the figure to hear clearly what they're saying" (Thiel, personal communication, January 31, 2021).

To make it feel like a finished and interactive piece, Thiel placed a great deal of importance on the audio so as to compel users to move around the 4D scene.

4. Artistic Style

Tilt Brush has evolved significantly since its launch. The original brush strokes of Tilt Brush were mostly flat, so artists needed to manoeuvre around 3D objects and colour each side separately. An enhancement to Tilt Brush called the hull brush allowed artists to paint volumetrically, enabling them to create characters and 3D scenes easily and quickly. Thiel, however, is of the opinion that Tilt Brush is not the best tool for creating realistic objects, but rather the most focused tool for visual style.

Optically, Tilt Brush gives you an exceptionally distinctive type of approach that is very hard to create. In comparison with other virtual reality–building tools like Quill or MasterpieceVR, surfaces could be made but they were not analogue in terms of style. “There is no way to create the style like Tilt Brush, unless you are built 3D models and put textures on them, or you can do it with just textures, but then they do not have the three dimensionalities”, Thiel states (Thiel, personal communication, January 31, 2021). In many other building systems, it is very difficult to create a surface structure that feels like a material structure. This form of granularity, this roughness on the surface, is something that Tilt Brush brings to virtual reality–building tools that the other tools do not.

Tilt Brush comes with an array of preinstalled brushes to experiment with. Thiel mentions that although Tilt Brush has its own palettes of brushes, it would confer great potential if users are able to create personal brushes. Similar to how a brush is created in Photoshop, artists would be able sketch something and define it as a brush to use. “I like brushes that are dynamic, like the pressure when you do

calligraphy or doing painting . . . If you could have more of that dynamism in the brushstrokes, that would also give you many more expressive possibilities," Thiel reflects (Thiel, personal communication, January 31, 2021).

Through the case study of Thiel, it is noted that Tilt Brush was conceived by a group of Western developers with Western conceptions of what a brush should be capable of. As each brush has its own dynamics, there is a huge range of brushes used in Eastern calligraphy. Should the Asians perspective have been included in development, the concept of what a brush should be capable of would be much broader.

While the process of starting to paint in Tilt Brush can be as simple as choosing from a variety of brushes, colours, and effects, the fact that it is easy makes it a little dangerous as well. According to Thiel, most of what she has seen so far in Tilt Brush are just cool scenes, without any depth to them. Since it is so easy to make something cool and pretty, artists do not attempt to convey what the artworks mean to them or the public. "You can make lots of pretty paintings in all art, but what is the necessity behind it, and why did you as an artist have to make this piece?" Thiel asks (Thiel, personal communication, January 31, 2021).

- **6.1.3. Artist – Kiki Wu**

Kiki Wu is a digital media artist who never had a formal education in traditional art. As her main medium is digital, she has no knowledge of how to traditionally paint and sculpt. Her perspective is important as she gives this study the viewpoint of an artist who started as a digital native and uses digital technologies to produce art.

When she was a student of communications in Taiwan, Wu started pursuing photography and filmmaking. Later in 2018, she enrolled in a digital media programme in America. She also participated in the Oculus Launch Pad Scholarship, a programme supporting new media artists on their VR development through hands-on training with industry leaders (Oculus, 2022). These initiatives started her journey into virtual reality and the Tilt Brush app.

1. Early Virtual Reality Experiments

Throughout Kiki Wu's artistic journey, she has always considered differences between mediums in her work. Her intention is to identify a suitable medium for a topic. She explains:

> "When I am trying to choose the types of medium, first, I would like to think about the difference between the medium and why I need to use this medium. Finally, to start thinking about what the best topic is for this medium" (Wu, personal communication, February 20, 2021).

Kiki Wu has explored many mediums and has tried generative art, video art, and eventually virtual reality art. Subsequently, her work has been centred around Tilt Brush because in virtual reality, audiences can feel embodied and immersive experiences. "I prefer to use Tilt Brush because I like to create an immersive environment for people to experience this larger-scale experience," she says.

Kiki Wu describes all her virtual reality paintings as being random and informal. Because she does not come from a traditional art background, she has not been limited to following traditional methods of creating art. She observes that "even though I do not have a traditional painting background, I find it easier to create art in

VR" (Wu, personal communication, February 20, 2021). In her opinion, Tilt Brush would be a very good tool for artists who have only previously practised traditional art or, like her, used digital media to express themselves in virtual reality. She adds that "some of my friends do not really have experience but can create very beautiful painting in Tilt Brush . . . and some of them who are proficient at painting can translate their work from paper to screen with precision" (Wu, personal communication, February 20, 2021). It is clear that as the virtual reality environment is 3D, they feel more in control.

Besides allowing her to create abstract art, virtual reality also enables her to consider how other people perceive art in an immersive environment. To her, "virtual reality not only allows you to practice art, but it also allows you to experience what is embodied in that virtual environment" (Wu, personal communication, February 20, 2021).

2. Oculus Launch Pad

Through the support of the Oculus Launch Pad scholarship, Kiki Wu set up her first virtual reality experience and experimented with painting in virtual reality. The programme is intended to provide support and guidance to virtual reality content creators from varying backgrounds and assist in bringing their innovative ideas to the market. Participants receive hardware support and are admitted to a kickoff boot camp event to help them grow in their fields. Through "hands-on training with industry leaders," this event aims to promote creators' "understanding and passion for VR development" (Oculus, 2022).

Kiki Wu mentions that through this programme, she learnt a lot of digital media literacy skills on current technologies, such as critical thinking, social media,

the internet, and data privacy. “These become a very important concept in my work,” she says (Wu, personal communication, February 20, 2021).

Wu believes that virtual reality has a positive future because she feels more people are getting into the technology due to its potential. Especially in the wake of the Covid-19 movement lockdowns, it has become critical for people to begin finding new ways of transferring everything to the virtual world. A “new role might arise in the future” (Wu, personal communication, February 20, 2021), since there is already a lot of demand for this in the animation and film industry, as many artists have already begun to use Tilt Brush to create short films. Having been part of Oculus Launch Pad, she knows more companies would want to invite developers, including artists, to their programmes. “They want to have more diverse opinions and diverse stories other than video games,” Wu says (Wu, personal communication, February 20, 2021). The developer community needs to engage a wide range of unique perspectives to grow a vibrant content ecosystem with mass appeal.

3. Artwork - Hidden Histories: Safe and Sound, 2021

Hidden Histories: Safe and Sound is a community project using AR and VR Tilt Brush technologies to engage the public with art inspired by the events and stories that have been a part of San Jose’s Japantown (Wu, 2021).

Designed as an immersive live performance, *Hidden Histories* engages the audience with the hidden beauty and rich heritage of this neighbourhood. By utilizing augmented reality technology, the mobile device becomes a gateway for visuals that were inspired by landmarks that shaped Japantown, and the audience will be able to interact with the art that is overlaid on present-day Japantown.

Figure 5: Kiki Wu, *Hidden Histories: Safe and Sound*, 2021

Inspiration - As part of *Hidden Histories*, Wu created art installations using Tilt Brush that were brought into the AR realm in the actual streets of Japantown. As an ethnically Chinese artist, one of her Tilt Brush installations is a drawing of a Chinese dragon that has a strong connection to her culture. "I love my culture, for me, that is a very comfortable way to express myself," she shares (Wu, personal communication, February 20, 2021). Additionally, she is particularly interested in the possibility of transferring cultural symbols into digital realms. Her goal was to find a new way to let people who are unfamiliar with her culture understand it better.

Additionally, she shares how she sometimes achieves peacefulness while painting with Tilt Brush, just like when she is meditating. "When I am doing Tilt Brush painting," she shares, "I start to think about how I can feel this kind of peacefulness in a virtual environment" (Wu, personal communication, February 20, 2021). Her goal was to explore these aspects as a guide to help people dealing with mental health issues. Therefore, many of her Tilt Brush paintings are like virtual temples, places where you can go and feel peace and serenity.

Creative Processes - In order to create *Hidden Histories*, Wu had to first conduct some research because its nature is very historical. Her next step was to create a prototype in virtual reality because most people, including production companies,

use Tilt Brush for prototyping VR projects, particularly for VR animation and VR films. She also found it to be an ideal prototyping tool for artists with little or no 3D knowledge. “Painting in a Tilt Brush environment is more comfortable since it’s easier to view a 3D model than other software,” she states (Wu, personal communication, February 20, 2021). She shares that this was the main reason why she used Tilt Brush as the prototyping tool for the painted 3D objects in the AR environment.

Although she has explored different types of softwares, she mainly uses Blender for 3D modelling, texturing, and animation, and Unity for game designing and importing into virtual reality. “The reason I used Tilt Brush is that I like this kind of intuitive way of creating art, so I do not have to do those 3D modelling,” she explains (Wu, personal communication, February 20, 2021).

In her experience, the drawback with Tilt Brush is that after importing a 3D object, for example from Blender, the complexity of the object causes Tilt Brush to slow down. Wu cautions users to be aware of using more detailed and complex 3D objects from other apps, as it may affect the performance when integrated into Tilt Brush or similar applications.

Artistic Style

To Kiki Wu, virtual reality, as compared to digital painting, gives artists a sense of space and scale, unlike a 2D experience. “When creating art in VR, I started thinking about providing a different perspective for the audience to look at and how they will interact with my art piece,” she highlights (Wu, personal communication, February 20, 2021). In addition, Wu likes the hand-drawn style, which she believes cannot be recreated in apps such as Blender. Hence, she uses Tilt Brush because she prefers a style that resembles traditional calligraphy and watercolour brush.

She believes that Tilt Brush has the potential to develop into a new expression form. Even though many of her friends do not have an art background, they feel comfortable painting within a VR environment. Since so many artists use Tilt Brush in a variety of ways, she believes there are no limitations on artistic styles. For her, it is more than just the final product. It is about how she can potentially use Tilt Brush artwork and animate it in the real world, just like her work *Hidden Histories*.

As an experienced Tilt Brush user with interests in animation and media, Wu wants to see more functionality and possibly more open-source content in Tilt Brush. She states an example: "if Tilt Brush offers a new type of interactive brush, like an interactive music brush, it will impact how people use it . . . I might try to use it and create a music video in Tilt Brush" (Wu, personal communication, February 20, 2021).

In response to the question of whether new technological innovations would impact her creative processes, Wu does not believe that they would affect her original concepts. "My idea will be the same, but I will be thinking about how I can apply it in a virtual reality environment," she adds. As a digital media artist, she has experience adapting to many types of technology. Even so, she recognizes that technology always affects her work and that she may need to adapt at times.

6.2. Participatory Research

This participatory study focused on the experience of artists when using Tilt Brush, and their opinions about the potential of virtual reality painting technology for art.

Besides analysing new media artists with backgrounds in creating virtual reality artworks, I have also surveyed artists with no prior artistic experience in applying virtual reality. This study will evaluate the participants' perspectives by assessing their experience and art-making processes. The participatory research will provide a clearer picture of both positive and negative encounters with VR, which could potentially be considered as universally shared by users of the same medium.

Participants have also been asked to use the virtual reality headset Oculus Quest and the painting app Tilt Brush to delve into design elements such as lines, tones, and textures when creating their artworks. They were then requested to share their creative experience of developing virtual reality artworks.

After collecting the data, an analysis was performed to identify how Tilt Brush has affected the creative processes of the artists.

- **6.2.1. Participants**

The participants were chosen based on their educational and/or professional backgrounds as digital media artists. They were required to have knowledge in art fundamentals and to be able to create art. All participants in the sample had little to no experience with virtual reality, and they had never used Tilt Brush before.

This experiment has allowed me to evaluate each participant's experience and identify advantages and challenges that come with the use of virtual reality, in addition to, or in lieu of, an artist's prior medium of choice.

- **6.2.2. Materials**

An Oculus Quest was used as the head-mounted device to operate Tilt Brush. To allow the principal investigator to observe what participants were painting in the

virtual environment, a monitor was set up. A voice recorder was used to record and administer the interview questions to participants on-site, while video conferencing was used for those who could not be physically present. With the consent of the interviewees, all discussions were recorded and transcribed into transcripts.

- **6.2.3. Procedures**

As a first step, the participatory research focused on familiarizing participants with virtual reality and guiding them through the use of the Tilt Brush tool kit, specifically on creating virtual artworks. A brief introduction was given to participants before the experiment, including a demonstration of how to wear and operate the Oculus Quest 2 headset and how to navigate the controllers.

To prepare for the process of creating a virtual painting, participants needed to complete a virtual reality tutorial through the virtual reality app First Steps. Developed by Oculus, First Steps is a highly acclaimed introduction to virtual reality. In this short overview of Oculus Quest, participants learnt about the controls and took their first steps in virtual reality. It also enabled participants to get a sense of the virtual environment and understand how to use the Oculus Touch controllers by interacting with a variety of objects. When the first session ended, participants were given a short break, after which Tilt Brush was introduced, and a demonstration on how to use it was shown.

In the second session, once participants had the headsets on, they were told to begin creating a virtual reality artwork. Participants were provided with additional instructions on how to get assistance when needed. Starting with a new sketch, participants were able to experiment with the Tilt Brush interface and various other options. There were no limitations on what the participant could create, and their use

of the painting app was documented throughout their process. Following the completion of their virtual reality artwork, participants were asked to remove their headsets and interviews were conducted with them.

6.3. Potential of Virtual Reality Painting Technology for Artistic Purposes

Artists could further explore the possibilities of virtual reality painting if they recognize its value and potential. The majority of participants rated their experience with Tilt Brush positively; in the interviews, several factors emerged that highlighted the potential uses of Tilt Brush for artistic ambitions.

- **6.3.1. Flexibility**

Majority participants expressed satisfaction in using Tilt Brush. The app's flexibility was one of the aspects that impressed them. One of the participants pointed out that its flexibility gave the ability to create things in virtual reality that would be impossible to achieve in the real world, due to laws of physics and other limitations. They found, additionally, that more senses could be activated in experimental ways, which would not be easily accomplished with other mediums.

One participant commented, "When I work in a medium, I like to make use of the medium. I will not attempt to make something like a flat painting in Tilt Brush because I can do that in Photoshop. My approach was always: Can I make something that is three-dimensional?"

- **6.3.2. Usability**

Participants were asked if they thought being tech-savvy was a requirement to use Tilt Brush, and what their experience was like when learning how to use the app's interface. They responded that they encountered minimal issues when using the app. Participants described their interactions with the controllers and the interface as "very

user friendly" and that they just needed a few tries to "get the hang of it." Additionally, one participant viewed the learning experience of the interface as "quite fun to do and play around with." Nevertheless, some participants mentioned that they still needed a bit of practice before they could use it, and that an artistic background is necessary if someone wants to draw well using Tilt Brush. One participant believed that it might be challenging for people of the older generation who are less comfortable with using digital devices.

Participants with digital media experience noticed that Tilt Brush offered tools such as colour pickers, brushes, undo, and erasers that are similar to Photoshop. As one participant pointed out, it really depended on what the person has already been exposed to. If they are familiar with using Photoshop or similar software, they should not have any issues: "I think it's not that difficult to transfer that knowledge into VR." Clearly, it is much easier for someone who works a lot with digital mediums to ease themselves into virtual reality.

Even so, for someone who has never worked with digital paintings before, learning to use the app may take some time. Despite that, they believe that if there is enough time, one could make a lot of the technical know-how understandable to most people.

- **6.3.3. Tools**

Tilt Brush offers multiple brushes and templates to its users, which could be used in the painting to highlight different aspects or achieve a particular aesthetic. Participants experienced a completely different painting experience when using Tilt Brush.

It has been noted that this different experience played a significant part in influencing participants' creativity. A participant expressed that she experienced a mindset change, and focused more on exploring what is possible in Tilt Brush, especially with the effects available: "The fact that I can easily get all these effects with just a click . . . It's going beyond what is limited in the current world and I am trying to think further on what can be done."

One participant shared that she explored the templates with different backgrounds when creating her first virtual reality artwork instead of starting with a blank canvas. After selecting the background, she experimented with the various brushes and added elements to decorate it. Another participant mentioned that she could easily try out the Tilt Brush tools that she had never used before, and it made the process much more creative. A number of participants commented on how much they appreciated the templates and effects available when using the different brushes.

- **6.3.4. Artistic Style**

There is a likelihood that Tilt Brush could lead artists to create new types of artwork, which raises the question: Will the advent of virtual reality lead to a new art form? According to most participants, there is definite potential of creating a new style that has never been seen before.

Participants' opinions on creating with Tilt Brush were generally positive. They stated that experimenting and trying out different styles and ways of doing things in virtual reality was a great opportunity, where they could see "a lot of potentials to come up with even better artworks." By utilizing new art mediums, creatives are potentially able to express themselves more creatively.

In one participant's view, the immersive feature that virtual reality offers has such a significant creative impact because new types of artworks can be developed where one can immerse oneself in the work, whereas "in other media, you are just an observer. Here, you are also a character." Due to the vast potential of this technology, one participant hoped that people will be able to figure out the context in which someone could use the painting application for a particular piece of work.

A participant anticipated that artists will be most intrigued by the technology. If it is well received, then people would want to experiment and explore this new medium. If popularity increases, then perhaps it would become mainstream and in turn, more unique and innovative artworks would be created.

Participants also believed that virtual reality painting technology will continue to only get better due to its immense potential. One participant commented, "In the past, such technologies were only seen in sci-fi movies, and to see them happening in my own life is amazing. I hope they can develop faster so I can be a part of it."

- **6.3.5. Sharing and Distribution of Art**

Due to the advent of the internet, virtual reality, as with other digital media, allows the sharing of artworks conceived using Tilt Brush on social platforms. It allows direct interactions from the public and fans with artworks.

During the interview section, participating artists discussed the shareable and potentially viral feature of virtual reality painting technology in terms of how it would benefit their artistic directions. Most thought that it would be great if more people see the artworks and are easily able to share them. "The more people have access to it, the better," a participant commented. He elaborated, "If the content is easily shareable and accessible, people won't have to visit a museum specifically to see it".

Since the Covid-19 pandemic, people have recognized the importance of having the ability to access everything from our homes through digital technology, such that physical travelling is not needed.

As a participant pointed out, however, there is a cause for concern in that only a small number of people currently own virtual reality headsets. Consequentially, this would impact artists, the way their works are distributed, as well as the extent of their reach. The participant also indicated that it is important to critically consider how an artwork could reach out to different parts of the world in various forms, and how it is distributed to people with no headsets to access the artwork.

- **6.3.6. Integration**

The ability to integrate other digital mediums with Tilt Brush allows participants of different backgrounds to see the potential benefits of virtual reality. Participants expressed interest in seeing how virtual reality could be seamlessly integrated with digital painting software such as Photoshop and Illustrator. “If these Adobe programs are available in VR, it will be interesting to see how we can create artwork with a tool that we are already familiar with, but with all the capabilities of VR.” Likewise, a 3D artist remarked that Tilt Brush’s integration of software, such as Maya, into VR will be beneficial in an “infinite” number of ways.

6.4. Limitations of Virtual Reality Painting Technology That Impacted Artists on Their Creative Processes

In the aforementioned Tilt Brush experiment, participants freely made virtual brushstroke s without being restricted by their artworks, but there was a limitation. It created an unorthodox experience that is different from how objects are perceived and interacted with in real life.

- **6.4.1. Tools Control**

Although participants said they could express themselves using Tilt Brush, most stated that it was not in the way that they had expected. They felt that 3D offered less control than 2D, and Tilt Brush was more difficult for the fine-tuning of artworks. Some participants mentioned that controlling the brush was difficult, and practice would be required to know how to manoeuvre the brush. One described that "it's okay navigating the tools in Tilt Brush, but it gets a bit hard to control the brushstroke. Getting a smooth brushstroke is difficult because I need to draw very fast, and when I'm fast, I can't draw small strokes." Another participant shared similar concerns: "Its limitations include my inability to make my brushstroke smooth. I can't control the opacity of the brushstroke, I can't erase just a little bit of my stroke (I must erase the whole stroke), and I am unable to make my artwork have gradients."

When comparing Tilt Brush to traditional methods in terms of control, a participant mentioned: "For example, on other software when you want to erase only a certain part, you can just erase it, but on Tilt Brush you really can't because you need to erase everything, unless you create different sections." Another participant commented that the program still has a lot of potential as compared to other software, citing Photoshop as an instance: "In Photoshop, I can plan, and I can get whatever result I want." She further elaborates, "There are layers in Photoshop whereas Tilt Brush is just one canvas on which I cannot crop and move things around." The limitations of Tilt Brush, it seems, had prevented her from creating the result that she intended.

It is hoped that further improvements would be made to the tool's control and layering. Participants indicated a need for features that were not found in Tilt Brush, showing a desire for greater control over the artworks they made.

- **6.4.2. Preinstalled Brushes and Template**

Although Tilt Brush provides a variety of brushes, effects, and backgrounds for its users, most participants felt that the options are rather limited. They felt that there could be more choices for creating artworks. One of them expressed, “I think there isn’t enough effects on the brushes provided, unless there is a plug-in like Photoshop that can be downloaded.”

Participants reported that they were unable to find the right tool for their respective artworks, so they faced difficulties drawing what they had in mind. Some did, however, feel that even though the tools are relatively limited, there were several options available that, as first-time virtual reality users, they had not been able to explore or consider.

Participants expressed concern that if the preinstalled templates remained the same, and no new ones were to be developed in the future, it would be quite limiting. One participant pointed out: “Because so many people can just only use the same few brushes and templates, more or less, it may look the same in some way.” Another also felt that the tools provided could be easily duplicated, are not unique, or are not in the form she originally envisioned them to be. “I think it does restrict the artist from unleashing their creativity potential,” another participant said.

Regardless of these limitations, some participants believed that virtual reality offered possibilities to do things in an extraordinary way, including having unique backgrounds or different stylizing brushes. They felt that the tool will change the way artists create, and that even if they started from a template, they could still create art that differed from others. “I think it’s not something conflicting with creativity,” said one participant.

- **6.4.3. Virtual Reality Headset**

A virtual reality headset is needed to enter an art scene created using Tilt Brush. Another limitation is that only one participant can view or create at a time with a single headset.

Nevertheless, one participant did not believe that this is an issue because, with a screen such as the one used in this participatory research, an individual could control the creation process while others viewed it through a screen. To this participant, this is the same concept as "I'm doing a painting or creating graphics in Illustrator, I'm the only one doing the edit, but many other people can see what I'm doing through the screen."

Yet, some participants expressed dissatisfaction as they noticed that while in Tilt Brush, the work created in the virtual space looked different than when viewed on the screen. A participant commented, "There's a lot of difference in the visuals, I'll have to pass my VR headset around so that others can experience it for themselves to see what the artwork looks like." Another added that a viewer through the screen "won't get the real effect of a virtual reality."

6.5. Features of Virtual Reality That Attract Artists to Its Use in Their Arts Practice

The experiment has shown participants that virtual reality environments provide an immersive and interactive experience, which allows them to paint anywhere within it. These special features are what attracted artists as they open new possibilities of artistic expression that would only come about within a virtual environment.

- **6.5.1. Immersion**

When asked what features of virtual reality appealed to them as artists, participants highlighted the app's immersive capabilities as one of the reasons to use it for their art practice.

Participants also described their experience in the immersive environment and why they enjoyed it. "Virtual reality is fun, and I like the fact that it's not too flat, it gives the impression of depth, there are a lot more things to experiment with than other mediums," one said. However, some of them initially did not interact well within the 3D space, and it took them time to adjust.

Another participant explained that with VR, she would not have to worry about having insufficient space if she needed to set up a large installation or artwork. Additionally, the teleporting tool was employed to minimize the need for participants to physically move while creating expansive art pieces. This tool enables instant teleportation to different locations within the virtual space, making it more convenient for artists to draw and design without the constraints of physical movement.

Participants also stated that in comparison to other mediums they had used, virtual reality's 3D nature allowed them to feel as though they were inside the artwork. "Unlike Photoshop, where I am just looking at the screen (two-dimensional space), it is not interactive and immersive," a participant compared. One of them added, "VR is very immersive where I feel like I am transported into a new dimension." Another participant reported having difficulties when using other software such as Rhino to create art in 3D spaces on the screen. Rhino requires artists to use a mouse for rotating and imagining the 3D space, but VR lets artists walk around, draw, and see what the outcome looks like within the same 3D space. She expressed that she preferred to "do

3D art in the air rather than inside the screen," because drawing what she sees around her helps in visualizing the art.

- **6.5.2. Presence**

Navigation is a mandatory part of virtual reality. To paint in 3D, one would have to drift through the virtual environment, which can be achieved through different methods. There are several options for movement within Tilt Brush, with no restriction on how participants move, whether they sat or stood, travel around the whole room, or remain stationary entirely. One additional option lets participants use the teleport function whenever they wanted to, without physically changing positions. As one participant described it, "Using the teleporting tool, I have no need to move around much, and can draw a whole landscape in the space."

Participants reported feeling comfortable when navigating the environment in Tilt Brush, because their movements mirrored their actions in the real world. Moreover, when walking in Tilt Brush, the distance covered corresponded to the distance in actuality. These factors, therefore, contributed to their sense of orientation and presence in the virtual environment.

It has been noted that several participants were at ease cruising through the virtual space due to the grid that appeared when they went near the boundaries. It enabled them to determine how much space was left to move around in, and they could move freely without any fear of knocking on to something as long as they remained within the boundaries.

Participants also stated that the immersion and presence features of virtual reality would be beneficial to their creative processes, as it made them feel as though they were part of the artworks in the virtual world. However, they believed that more

practice would be needed to use the brush effectively and master the control of its depth.

One participant elaborated that since it was their first time using virtual reality, the main objective was to understand the concept of the virtual space and to learn how to use the tools. Participants were also interested in exploring how different tools could create varying effects when using them in conjunction with each other. In addition, they discovered how viewing from different angles affected the perception of space. “It is to get to know the environment, something that can be quite interesting as an artist to explore,” one said. Participants believed that there was more flexibility in the way things could be approached since the immersive feature potentially allowed them to unravel a wide range of styles and techniques without feeling constrained by physical space.

- **6.5.3. Interactivity**

Interactivity was also an appealing reason for artists to adopt virtual reality in their art practices. It is noted that Tilt Brush enabled participants to create and paint 3D objects, enhanced with particles and scenes that could be easily manipulated. This gave them a sense of depth and an interactive experience that they would not get from real paint brushes. One participant remarked that due to the proximity between artists and their artworks, they see their creations from top to bottom, at eye level, and are able to interact directly with the art. “I learned that painting may not just be a two dimensions thing, it can be three dimensions where you can interact with your artwork.”

Even though virtual reality allows users to make a painting and walk through the space in a 3D manner, one participant appreciated that he was able to make hybrid

sculptural forms of artwork within the digital environment. Through virtual reality, he was able to make an object with volume, and walk around and appreciate it, as compared to a 2D, flat surface that is impossible to interact with and be immersed in.

In addition, immediacy was the reason why he chose virtual reality over other digital mediums, because VR was similar to "when we work with pencil and paper in real life, like physical connection: you make a mark, you see it." In contrast, when using digital tools such as drawing tablets for creating artworks, there is a mismatch between the distance moved by the hand and the distance moved on the screen. As participants carved marks on a digital canvas with a pliability resembling paper, virtual reality could minimize the gap of what they would normally experience when creating in real life. Another participant added, "At the end of the day, art is about engaging all the senses." VR's ability to engage more senses and convey different feelings to viewers would allow art to be produced at a greater variety and depth.

6.6. Challenges and Difficulties Artists Face When Using Virtual Reality

- **6.6.1. Size and Weight**

It is noted that participants faced some challenges and difficulties with the virtual reality headset as it is bulky and inconvenient to wear. For instance, the headset chafes against all kinds of hairstyles and wearing it with glasses on was deemed bothersome to some.

Some felt that the virtual reality headset should be much smaller: "I do agree, when I first tried on the headset, that it is heavier than I expected it to be," one shared. Another suggested, "I think the main thing they have to consider now is the size of the headset." Generally, the participants believed that "in the future, the size [of the headset] will definitely get smaller."

Due to the weight of the head-mounted device, it can be exhausting to stand and move around for an extended time, leading to usability issues that caused participants to become tired while using it. Although they did not use it for a long duration, participants commented that they did not expect it to be "pleasant to use it for a long period, especially for creation." Some participants, however, believed that with regular use, there will be improvements. "Over time, I get more adapted to the weight of it, and probably the usage of it. I think that it is not a critical issue," one shared. They speculated that it would not be a critical problem because when tiredness does occur, they could always take a break.

- **6.6.2. Motion Sickness**

Virtual reality systems are known to cause motion sickness. As the experiment lasted for a short period of time, however, the participants only mildly experienced this side effect.

The majority of participants stated that they "do feel a bit of giddiness, but after a while, I felt okay," or: "Not really, I didn't experience any dizziness as much." Nevertheless, they speculated that there is a possibility that motion sickness could happen if they spent longer hours using it. Another participant also revealed that because he was focused on the creative process, he did not feel anything until the experiment ended. "While in the process, you won't think about it," he remarked.

One participant pointed out that because their experiment artwork was static, motion sickness did not have much impact. If the artwork involved movement, however, it is likely that the working process would affect the brain and cause dizziness or headaches. Participants also doubted that people would be able to use virtual reality for very long periods of time without frequent breaks.

- **6.6.3. Technological Change**

Due to the rapid technological advancement, artworks done with virtual reality may become inaccessible if a system is eventually not compatible with the current technology. This posed a concern to participants as practising artists. As a result, they would factor this into their decision on whether to use virtual reality for their artwork. “If I take hours to draw a whole landscape and then 10 years down the road, I can’t open up my file or I can’t edit anymore, my work will become redundant and wasted without the technology,” one stated.

On the other hand, most were optimistic about mitigating these potential issues, and expected that technological advancements would address compatibility issues as well. But in terms of the possibility of virtual reality being “cancelled”, they “don’t think it will happen”—VR was something they felt would be “future proof.” Even if virtual reality were to be gone, they mentioned that technological development would allow for a streamlined experience that could be viewed anywhere. For instance, artworks could also be viewed through a 2D screen, just by “rotating” them and configuring the screen.

- **6.6.4. Tactile Feedback**

When using virtual reality in their artworks, one of the major challenges and difficulties that participants experienced was a lack of tactility: “The difficulty with VR is that there’s no tactile feedback. Since you’re moving in the air, there’s no resistance, so you are unable to feel surfaces,” one participant shared, stating that this affected their creative process.

Due to the depth of the virtual space, the sense of touch is inaccurate. Participants thought that they were touching something, but it was in fact not there.

“Because you can’t see your arm, that was pretty tricky,” said one participant. Gauging where strokes land in space was a complication, especially for participants who were new to VR.

A participant shared her challenge making VR art: “I can’t really draw directly on the snowman. If I had drawn a bit too far or too near, [the painting stroke) will be floating or will disappear inside the snowman.”

Participants also raised concerns about not being able to “feel the artwork when is done, such as the textures.” The lack of sense of touch created a barrier to achieving certain intended effects, despite their ability to manipulate the brushes or see their artworks.

Additionally, virtual reality does not offer the ability to adjust the pressure of strokes, unlike when working on a traditional medium, like pencil and paper, or even on Photoshop. The main difficulty that VR systems should address is the fact that people are unable to feel what they are drawing, which results in their inability to feel the context of the brush on the paper. As there is no solution to that problem yet, one participant commented that “sometimes you just have to work with the limitation of the medium.” It is hoped that technology eventually provides touch simulation, so that “when you see something in VR, you can feel and sense it.”

Participants felt that virtual reality offers a more intuitive and natural approach to exploring and looking around. Conversely, when it came to creating, participants were not as certain, and they thought that it might be difficult to work with. It basically “challenges the conventional frame of a painting and brings into question the nature of boundaries in the act and object of painting,” like one participant shared.

7. FINDINGS

7.1. Potential of Virtual Reality Painting Technology for Artistic Purposes

Interviews and questionnaires conducted with two categories of artists (virtual reality artists and artists with no prior experience with virtual reality) have provided various insights on what aspects would potentially affect the usability of Tilt Brush for artistic purposes. In this section, I will present the study findings by analysing and summarizing the responses of the artists interviewed, thereby providing solutions for each outcome.

- 7.1.1. Flexibility

While Tilt Brush has its limitation, artists generally found virtual reality painting apps to be a great tool in creating artworks, or to help express themselves in ways that they might not be able to when using other mediums.

The interviews revealed that virtual reality painting technology provides artists with the flexibility to experiment with different techniques and styles, regardless of their background in painting. Artists expressed a sense of control as they are not restricted to traditional methods of creating art. This flexibility empowers artists from diverse backgrounds to engage in artistic expression, and adapt to the changing art landscape.

From this study, we learnt how virtual reality has been applied by artists to further their artistic ambitions. Virtual reality can be manipulated and enhanced in ways that are impossible in the physical world, thus allowing more senses to be activated in experimental manners, which would be difficult to accomplish in other mediums.

- **7.1.2. Usability**

The findings indicate that Tilt Brush is highly usable, particularly for artists with prior experience using digital media. The familiar interface and navigation make it easier for artists to apply their traditional digital art skills to this medium. Artists without prior experience with digital technologies may require more time to grasp the app. This usability expands the range of artistic voices and fosters inclusivity within the art community.

- **7.1.3. Tools**

According to the artists interviewed, the availability of various brushes and templates in Tilt Brush is one of its appealing aspects for artistic purposes. The tools provided in Tilt Brush offer distinct brushstrokes, textures, and compositions that are difficult to achieve through other apps. This range of tools and effects democratizes access to different artistic styles and techniques, allowing artists from different socioeconomic backgrounds to explore and express their creativity.

A commitment to understanding the medium, and differences between the brushes, was evident in the artists' use of the tools provided. It helped them to improve their abilities and achieve different aesthetics.

- **7.1.4. Artistic Style**

Virtual reality painting technology's immersive feature and tools contribute to the development of new artistic styles. Artists expressed that experimenting with different techniques and methods in virtual reality, through Tilt Brush, provided them with opportunities for creative expression and helped them create artworks they had never thought of before. This development of new artistic styles fosters innovation and

diversity in the art field, attracting a wider audience and potentially creating new market opportunities.

This development of new artistic styles within virtual reality has significant implications for the art industry. The exceptional and captivating nature of these artworks attracts a wider audience, transcending traditional art boundaries, and appeals to individuals who may not have been previously engaged with art. This increased audience interest creates opportunities for artists to showcase their work to a broader demographic and potentially makes new market opportunities. The innovative and immersive experiences provided by virtual reality painting technology hold the potential to reshape the art landscape and open new avenues for artistic exploration and commercial success.

- **7.1.5. Sharing and Distribution of Art**

Artists acknowledged the benefits of sharing artworks created in virtual reality through the internet and social media platforms. They mentioned that it allows for a wider audience reach and facilitates engagement and interaction with diverse viewers. This sharing and distribution aspect provides artists with a platform to showcase their work, gain exposure, and potentially generate income, breaking down geographical barriers and fostering connections between artists and art enthusiasts.

The prevalence of virtual reality technology has encouraged many artists to get involved, especially in the wake of the Covid-19 pandemic. Recognizing the significance of having online access to artworks, they began finding new ways to transfer everything into the virtual world. This shift underscores the increasing importance of virtual platforms in the art realm and reflects artists' adaptability and resilience in the face of challenging circumstances.

Virtual reality painting technology has provided artists with an alternative means of creative expression and connection with audiences when physical interactions and exhibitions are limited. The study found that the availability of virtual reality painting tools like Tilt Brush democratizes access to artistic expression. It allows artists from different socioeconomic backgrounds to explore and engage in the art form, as virtual reality equipment becomes more affordable and accessible.

This accessibility expands the range of artistic voices and promotes inclusivity within the art community by breaking down barriers to entry that may have existed in traditional art mediums.

- **7.1.6. Integration**

Tilt Brush's ability to integrate with other digital mediums has enabled artists from different artistic backgrounds to see the benefits of virtual reality. With all the capabilities provided by virtual reality, artists can further enhance their new or existing artworks from other digital technologies and incorporate new elements.

This aspect of integration gives artists the ability to adjust to the dynamic art environment. Additionally, it assists them in broadening their artistic expertise and interacting with a wider public. It promotes cross-disciplinary partnerships and supports creative individuals in delving into the integration of art and technology and inspires innovation and creativity in the age of technological art. Particularly, creative individuals who can afford the required tools and utilize virtual reality platforms are able to involve themselves in interdisciplinary partnerships and establish connections with other artists. That is attainable regardless of geographic limitations. This collaborative aspect can foster the exchange of ideas, skills, and resources, leading to

collective growth and potentially influencing the socioeconomic dynamics of the art community.

7.2. Limitations of Virtual Reality Painting Technology That Impacted Artists' Creative Processes

The study identified several limitations that have been observed to impact artists during their creative processes when using virtual reality painting technology.

- 7.2.1. Tools Control Function

Despite its many advantages, Tilt Brush does not give artists the level of control they want over brush movements. This lack of control might be ascribed to users' misinterpretations of the programme's capabilities and the absence of some features, such as layering, that are seen in other programmes like Photoshop. This constraint raises concerns for artists, particularly those with substantial virtual reality expertise, because it interferes with their creative processes and limits their capacity to fine-tune their artworks.

- 7.2.2. Preinstalled Brushes and Templates

The limited set of preinstalled brushes and templates in Tilt Brush presents a challenge for artists in finding the right tools for their artistic visions. This limitation restricts their creative possibilities and makes it difficult for them to bring their ideas to life. While some artists believe that the tools provide flexibility for personalized working methods, it ultimately depends on how artists use it. Additionally, the inclusion of more brushes and templates in the future may risk giving rise to unoriginal artworks if new and diverse options are not developed.

- **7.2.3. Virtual Reality Headset**

The requirement of wearing a virtual reality headset to create and experience Tilt Brush art is a concern raised by artists. The lack of multiuser capabilities restricts artists' ability to socialize and expose their works to a wider audience, denying them of different perspectives. Collaborative work is particularly affected, as only one individual can view or create at a time with a single headset. This limitation poses challenges to the creative processes of artists. While it is possible for non-headset users to view artworks on a screen, the visual and immersive experience is fundamentally different.

Additionally, the cost of purchasing multiple headsets may deter artists from fully embracing virtual reality painting, if multiple devices continue to be required for multiple users. By addressing these limitations, artists would be able to better navigate the virtual reality painting landscape and enhance their creative processes.

7.3. Features of Virtual Reality That Attract Artists to Its Use in Their Arts Practice

In this study, virtual reality environments were shown to provide an immersive presence and interactive experience that attract artists because they allow for new possibilities of artistic expression.

- **7.3.1. Immersion**

The immersive characteristic of virtual reality provides artists with more opportunities for experimentation compared to other mediums, as it equips them with a sense of being a part of the artwork. This immersive quality enhances their creative processes, offering audiences a new perspective on the artwork. Additionally, the space in virtual reality allows artists the freedom to create large installations or

artwork without space restrictions, further enhancing the sense of immersion and embodiment.

- **7.3.2. Presence**

Virtual reality offers a gestural experience, where the hand becomes the brush, and the immersive space becomes the canvas. Navigating through the virtual environment is an important feature for artists, as it allows them to create in three dimensions and accommodates their distinct preferences for movement. By mirroring their real-world movements, artists achieve a sense of realism in their virtual creations. This aspect of presence enables artists to orient themselves in the virtual environment and feel more engaged, creating artwork in a manner similar to real-world experiences.

- **7.3.3. Interactivity**

Interactivity is another characteristic that inspires artists to use virtual reality in their art practice. The experience of depth offered by virtual reality cannot be matched by any other medium. By being physically near their artworks, artists have the ability to establish a 3D experience that facilitates interaction between themselves and their works. This ability to make hybrid sculptural forms within a digital environment opens up new opportunities for artists to create interactive and immersive artworks. Engaging all senses, virtual reality allows artists to express themselves more freely and convey a variety of feelings to viewers, leading to greater depth and diversity in their work.

By incorporating these features of virtual reality into their art practices, artists fully experience the possibilities offered by the virtual environment. The depth and

interactivity provided by virtual reality make it an appealing medium for artistic expression.

7.4. Challenges and Difficulties Artists Face When Using Virtual Reality

The study revealed several challenges and difficulties that artists encounter when using virtual reality.

- **7.4.1. Virtual Reality Headset**

Artists expressed concerns about the virtual reality headset itself, noting that it can be heavy and inconvenient to wear. Additionally, motion sickness is a common side effect of virtual reality systems, which can be less severe for artists using it for short periods, but may become more pronounced with prolonged usage. Artists like Kiki Wu have voiced their struggles with fatigue and limited endurance in virtual reality, leading to potential usability problems that hinder their ability to create artworks.

- **7.4.2. Technological Change**

Another challenge is the rapid pace of technological change. Advancements in technology are happening so quickly that artworks created using virtual reality could become inaccessible if new systems are not compatible with them. This raises the issue of potential obsolescence and wastage of artistic works as technology evolves, posing a challenge for artists. However, despite this concern, most artists remain optimistic, believing that future technological advancements will address these compatibility issues.

- **7.4.3. Tactile Feedback**

The lack of tactile feedback presents a significant challenge for artists in virtual reality. Unlike traditional or other digital mediums, virtual reality artists are

unable to physically feel the subject they are creating. Having no sense of touch in the virtual space creates confusion, which affects their creative processes. It can be difficult for artists to navigate and engage fully with their creations due to the depth of the virtual space. Taking these challenges into account and taking steps to address them will enable artists to overcome the limitations of virtual reality and maximize its unique potential.

8. CONCLUSION

In conclusion, this research study explored the potential of virtual reality painting technology for artistic purposes. The findings provide valuable insights into the usability and impact of virtual reality painting, specifically focusing on the app Tilt Brush. Through interviews and questionnaires with artists from diverse backgrounds, this study has shed light on various aspects that influence the use of virtual reality painting technology in the artistic community.

The findings of this study demonstrate the significant potential of virtual reality painting technology in enhancing artists' creative processes and expanding artistic expression. Artists expressed a sense of flexibility, control, and empowerment when using Tilt Brush, as it allows them to experiment with different techniques and styles. The availability of various brushes and templates in Tilt Brush broadens the range of artistic possibilities and fosters inclusivity within the art community. Additionally, the usability of Tilt Brush, particularly for artists with prior experience in digital media, enables them to apply their existing skills and explore new artistic horizons.

Virtual reality painting technology offers immersive and interactive experiences that attract artists. The immersive nature of virtual reality allows artists to

engage in experimental creation without the limitations of physical space. The presence and interactivity of the medium enhance artists' connection with their artworks and enable them to create unique and immersive experiences for viewers. Virtual reality also provides artists with the digital potential of sharing and distributing their artworks, transcending geographical boundaries and fostering connections with a wider audience.

However, it is important to acknowledge the limitations of this research study. The focus on Tilt Brush as a representative virtual reality painting app may not fully capture the experiences and perspectives of artists using other similar apps. Additionally, the sample size of artists interviewed and surveyed may not be fully representative of the entire artistic community, which could limit the generalizability of the findings.

Future research can expand on this study by investigating a wider range of virtual reality painting apps and including a larger and more diverse sample of artists. Further exploration of the identified limitations, such as the control over brush movements and the availability of brushes and templates, can guide the future development of improved virtual reality painting tools. Additionally, studying the long-term effects of virtual reality painting on artistic practices and addressing the challenges and difficulties faced by artists, such as the discomfort of wearing a virtual reality headset, can further enhance the potential of virtual reality in the art realm.

In conclusion, this research study has highlighted the potential of virtual reality painting technology for artistic purposes. The findings emphasize the positive impact of virtual reality on artists' creative processes, artistic expression, and engagement with audiences. Virtual reality painting technology has the ability to revolutionize the

art landscape, democratize artistic expression, foster inclusivity, and inspire innovation. By addressing the limitations and challenges identified, future advancements in virtual reality painting technology can unlock its full potential, providing artists with new tools and opportunities for artistic exploration and expression.

9. BIBLIOGRAPHY

ARTDEX. (2020, June 24). *How technology is changing the art world*. https://www.artdex.com/how-technology-is-changing-the-art-world-2

Artfinder. (2019, July 15). *Turning virtual art into a virtual reality*. https://www.artfinder.com/blog/post/turning-virtual-art-into-virtual-reality/

Ascott, R. (1999). Seeing double: Art and the technology of transcendence. In Ascott, R. (Ed.), *Reframing consciousness: Consequences of art through technology* (pp. 66–71). Intellect Books.

Auganix. (2021, April 19). *Masterpiece Studio announces release of its complete virtual reality 3D creative suite 'Masterpiece Studio Pro'*. Auganix. https://www.auganix.org/masterpiece-studio-announces-release-of-its-complete-virtual-reality-3d-creative-suite-masterpiece-studio-pro/

Avila, L., & Bailey, M. (2016). Art in the digital age. *IEEE Computer Graphics and Applications, 36*(4), 6–7. https://doi.org/10.1109/MCG.2016.77

Bates, J. (1992). Virtual reality, art, and entertainment. *Presence: Teleoperators and Virtual Environments, 1*(1), 133–38. https://doi.org/10.1162/pres.1992.1.1.133

BBC. (2021, January 27). *Google's Tilt Brush VR painting app goes open source*. https://www.bbc.com/news/technology-55826249

Bitner, J. (2018, January 3). *VR art: Tools & examples*. Lullabot. https://www.lullabot.com/articles/vr-art-tools-examples

Bolas, M. (2001). The development of virtual reality. *IEEE Computer Graphics and Applications, 21*.

Boldyreva, N. (2018, April). *Exploiting the potential of virtual reality: Innovative practices in museums* [Master's thesis defence presentation, LASALLE College of the Arts]. Singapore. https://www.researchgate.net/publication/325063082_Exploiting_the_potential_of_virtual_reality_innovative_practices_in_museums

Borges J., E., & Di Felice, M. (2018). The post-virtual reality: From the interactive experience to the connective experience. In A. L. Brooks, E. Brooks, & N. Vidakis (Eds.), *Interactivity, game creation, design, learning, and innovation: 6th international conference, ArtsIT 2017, and second international conference, DLI 2017, Heraklion, Crete, Greece, October 30–31, 2017, Proceedings* (pp. 204–12). Springer Cham. https://doi.org/10.1007/978-3-319-76908-0_20

Bown, J., White, E., & Boopalan, A. (2017). Looking for the ultimate display: A brief history of virtual reality. In J. Gackenbach & J. Bown (Eds.), *Boundaries of self and reality Online: Implications of digitally constructed realities* (pp. 239–59). Academic Press. https://doi.org/10.1016/b978-0-12-804157-4.00012-8

Breia, R. (2021, September 9). *Best tools for VR painting, sculpting and 3D modeling*. Sensorium XR. https://sensoriumxr.com/articles/best-vr-tools-painting-sculpting-modeling

Chafkin, M. (2015, October). Why Facebook's $2 billion bet on Oculus Rift might one day connect everyone on earth. *Vanity Fair*. https://www.vanityfair.com/news/2015/09/oculus-rift-mark-zuckerberg-cover-story-palmer-luckey

Chang, E., Kim, H. T., & Yoo, B. (2020). Virtual reality sickness: A review of causes and measurements. *International Journal of Human–Computer Interaction, 36*(17), 1658–82. https://doi.org/10.1080/10447318.2020.1778351

Chattha, U. A., Janjua, U. I., Anwar, F., Madni, T. M., Cheema, M. F., & Janjua, S. I. (2020). Motion sickness in virtual reality: An empirical evaluation. *IEEE Access, 8*, 130486–99. https://doi.org/10.1109/access.2020.3007076

Chittenden, T. (2018). Tilt Brush painting: Chronotopic adventures in a physical-virtual threshold. *Journal of Contemporary Painting, 4*(2), 381–403. https://doi.org/10.1386/jcp.4.2.381_1

Cipresso, P., Giglioli, I. A. C., Raya, M. A., & Riva, G. (2018). The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. *Frontiers in Psychology, 9*. https://doi.org/10.3389/fpsyg.2018.02086

CNN. (2016, May). Google Tilt Brush: Impossible now a reality? https://edition.cnn.com/style/article/google-tilt-brush/index.html

Cui, J. (2017). Research on digital painting art and its diversified performance. In Hou, Y., & Zheng, W. (Eds.), *Proceedings of the 2017 3rd international conference on economics, social science, arts, education and management engineering (ESSAEME 2017)* (pp. 1429–32). Atlantis Press. https://doi.org/10.2991/essaeme-17.2017.295

Davies, C. (1995). *Osmose* [Virtual reality installation]. http://www.immersence.com/osmose/index.php

Dick, E. (2021, June 1). *Risks and challenges for inclusive and equitable immersive experiences*. Information Technology and Innovation Foundation. https://itif.org/publications/2021/06/01/risks-and-challenges-inclusive-and-equitable-immersive-experiences/

Engasser, F. (2016, December 29). *A new artistic approach to virtual reality*. The Long + Short. https://thelongandshort.org/creativity/future-virtual-reality-art

Ethmology, D. O. (2022). Virtual Reality.

Fearn, N. (2016, December 3). *Painting a new perspective: How virtual reality is transforming art.* TechRadar. https://www.techradar.com/sg/news/painting-a-new-perspective-how-virtual-reality-is-transforming-art

Gamboa, S. (2018). *The influence of technology in art appreciation and sales as a factor in the sustainability of the retail art industry* [Undergraduate thesis, University of South Florida]. Muma College of Business Business Honors Program Thesis Library.

Gobbetti, E., & Scateni, R. (1998). Virtual reality: Past, present and future. *Studies in Health Technology and Informatics 58*(3), 3–20. https://doi.org/10.3233/978-1-60750-902-8-3

Haar, R. T. (2005). Virtual reality in the military: Present and future. In *Proceedings of 3rd Twente Student Conference on IT , Enschede June, 2005*. University of Twente, Faculty of Electrical Engineering, Mathematics and Computer Science.

Hacmun, I., Regev, D., & Salomon, R. (2018). The principles of art therapy in virtual reality. *Frontiers in Psychology 9*. https://doi.org/10.3389/fpsyg.2018.02082

Harley, D. (2019). Palmer Luckey and the rise of contemporary virtual reality. *Convergence: The International Journal of Research into New Media Technologies, 26*(5–6), 1144–58. https://doi.org/10.1177/1354856519860237

Harris, M. (2018, September 7). *7 best tools for painting, 3D modelling and sculpting in VR*. Digital Arts. https://web.archive.org/web/20230306173505/https://www.digitalartsonline.co.uk/features/hacking-maker/7-best-tools-for-painting-3d-modelling-sculpting-in-vr/

Hasan B., & Throsby, C. D. (2010). Culture of innovation: An economic analysis of innovation in arts and cultural organisations. NESTA. https://media.nesta.org.uk/documents/culture_of_innovation.pdf

Hayden, S. (2021, January 27). *Google makes 'Tilt Brush' open source as active development comes to a halt.* Road to VR. https://www.roadtovr.com/google-tilt-brush-open-source/

Holt, K. (2021, September 17). *Facebook hands over VR painting and animation app Quill to its creator*. Engadget. https://www.engadget.com/facebook-quill-vr-illustration-tool-inigo-quilez-181549077.html

Hooper-Greenhill, E. (2000). *Museums and the interpretation of visual culture*. Routledge. https://doi.org/10.4324/9781003124450

Hutchison, A. (2007). Back to the Holodeck: New life for virtual reality? In *Proceedings of the 2nd international conference on Digital interactive media in entertainment and arts* (pp. 98–104). Association for Computing Machinery. https://doi.org/10.1145/1306813.1306838

Immersive Learning News. (2021, February 9). *Tilt Brush gains multiplayer with MultiBrush for Oculus Quest.* https://www.immersivelearning.news/2021/02/09/tilt-brush-gains-multiplayer-with-multibrush-for-oculus-quest/

Inglese, C. & Ippolito, A. (Eds.). (2019). *Analysis, conservation, and restoration of tangible and intangible cultural heritage*. IGI Global. https://doi.org/10.4018/978-1-5225-6936-7

Jagneaux, D. (2021, February 5). *MultiBrush is a free multiplayer version Of Tilt Brush out now for Quest.* Upload. https://uploadvr.com/multibrush-free-multiplayer-tilt-brush-quest

Kim, B. (2016). *Virtual reality as an artistic medium: A study on creative projects using contemporary head-mounted displays* [Master's thesis, Aalto University]. Aalto University Learning Centre.

Kunnumpurath, B., & Stephen, C. (Eds.). (2023). *Virtual reality and new media (VRNM): Vol I*. Native Tribe.

Lang, B. (2021, January 8). *'Tilt Brush' co-creator leaves Google for 'very special' VR project with 'Space Pirate Trainer' studio*. Road to VR. https://www.roadtovr.com/tilt-brush-patrick-hackett-i-illusions-vr-collaboration/

Lanier, J., & Biocca, F. (1992). An insider's view of the future of virtual reality. *Journal of Communication, 42*(4), 150–72. https://doi.org/10.1111/j.1460-2466.1992.tb00816.x

Lepouras, G., & Vassilakis, C. (2004). Virtual museums for all: Employing game technology for edutainment. *Virtual Reality, 8*, 96–106. https://doi.org/10.1007/s10055-004-0141-1

Liu, H. (2021). Application and development of VR technology in painting. *Journal of Physics: Conference Series, 1744*(042225). https://doi.org/10.1088/1742-6596/1744/4/042225

Mandal, S. (2013). Brief introduction of virtual reality & its challenges. *International Journal of Scientific & Engineering Research, 4*(4), 304–9.

Manovich, L. (2002). *The language of new media*. MIT Press.

Matney, L. (2018, February 9). *Facebook brings animation tools to its Quill VR painting app*. TechCrunch. https://techcrunch.com/2018/02/08/facebook-brings-animation-tools-to-its-quill-vr-painting-app/

Mazuryk, T., & Gervautz, M. (1999). Virtual reality: History, applications, technology and future.

McMahan, A. (2003). Immersion, engagement, and presence: A method for analyzing 3-D video games. In M. J. P. Wolf & B. Perron (Eds.), *The Video Game Theory Reader* (pp. 67–86). Routledge. https://doi.org/10.4324/9780203700457

Melnick, K. (2021, January 27). *Google ends support of 'Tilt Brush,' software now open source*. VRScout. https://vrscout.com/news/google-ends-support-tilt-brush-open-source

Mertz, L. (2019). Virtual reality pioneer Tom Furness on the past, present, and future of VR in health care. *IEEE Pulse, 10*(3), 9–11. https://doi.org/10.1109/mpuls.2019.2911808

Meta. (2022). *Oculus Launch Pad Program*. Oculus. https://developer.oculus.com/launch-pad/

Mileva, G. (2021, October 14). *Sabby Life is changing the way we view art with VR art.* ARPost. https://arpost.co/2021/10/14/sabby-life-changing-we-view-art-vr-art

MOR. (2020, January 22). *The Beginner's Guide to VR Art Creation Apps in 2020*. Museum of Other Realities (MOR). https://www.museumor.com/blog/beginners-guide-to-vr-art-creation-apps

Mütterlein, J. (2018). The three pillars of virtual reality? Investigating the roles of immersion, presence, and interactivity. In *Proceedings of the 51st Hawaii international conference on system sciences, 2018* (pp. 1407–15). Hawaii International Conference on System Sciences. https://doi.org/10.24251/HICSS.2018.174

Muzaffar, A. (2020, September 9). *A spin in the multiverse of Sabby Lighf.* Museum of Other Realities (MOR). https://www.museumor.com/blog/a-spin-in-the-multiverse-of-sabby-lighf

Paul, C. (2015). *Digital Art* (3rd ed.). Thames & Hudson.

Powell J., L. G. (2018, December 25). *Seeing art through a new lens with VR: An interview with The Sabby Life.* Medium. https://lancegpowelljr.medium.com/seeing-art-through-a-new-lens-with-vr-an-interview-with-the-sabby-life-e0b13262a96a

Quill. (n.d.). *Quill*. https://quill.fb.com/

Ramsier, L. E. (2019). *Evaluating the usability and user experience of a virtual reality painting application* [Master's thesis, University of North Carolina at Chapel Hill]. Carolina Digital Repository. https://doi.org/10.17615/s9z1-m163

Robertson, A., & Zelenko, M. (2014, August). *Voices from a virtual past: An oral history of a technology whose time has come again*. The Verge. https://www.theverge.com/a/virtual-reality/oral_history

S3ART Store. (2021, September 7). The 10 best virtual reality applications for artists. https://s3artstore.com/blogs/magazine/10-best-vr-apps-for-artists

Sabrina. (2023). *VR Artist & Performer | TheSabbyLife*. TheSabbyLife. https://www.thesabbylife.com/

Sajjadi, P. (2022). *Immersion, Presence, and Interaction* [Lecture notes]. *3D Modeling And Virtual Reality.* Department of Geography, The Pennsylvania State University. https://www.e-education.psu.edu/geogvr/node/875

Schaaf, A. J. (2019). *Tilt Brush: The Utilization of a Virtual Reality Intervention for Evaluating Self-Reported Anxiety, Depression, & Stress.* University of Cincinnati.

Schubert, T., Friedmann, F., & Regenbrecht, H. (1999). Embodied presence in virtual environments. In R. Paton & I. Neilson (Eds.), *Visual representations and interpretations* (pp. 269–78). Springer. https://doi.org/10.1007/978-1-4471-0563-3_30

Serota, N. (1996). *Experience or interpretation: The dilemma of museums of modern art.* Thames and Hudson.

Shehade, M., & Stylianou-Lambert, T. (2020). Virtual reality in museums: Exploring the experiences of museum professionals. *Virtual reality and its application in cultural heritage*. Special issue of *Applied Sciences, 10*(4031). https://doi.org/10.3390/app10114031

Smithsonian Institution. (2016, October 4). Smithsonian American Art Museum releases "Renwick Gallery WONDER 360" virtual reality app [Press release no. SI-500-2016]. https://www.si.edu/newsdesk/releases/smithsonian-american-art-museum-releases-renwick-gallery-wonder-360-virtual-reality-app

Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of Communication, 42*(4), 73–93. https://doi.org/10.1111/j.1460-2466.1992.tb00812.x

Stewart, R. (2017, March 17). *Is virtual reality the future of art*? DW. https://www.dw.com/en/is-virtual-reality-the-future-of-art/a-37942941

Suppa, C. (2017, August 16). *The future of art is nigh at Erie Movie House and Artlore Studio*. Erie Reader. https://www.eriereader.com/article/the-future-of-art-is-nigh-at-erie-movie-house-and-artlore-studio

Sutherland, I. E. (1968). A head-mounted three dimensional display. In *Proceedings of the December 9-11, 1968, fall joint computer conference, part I* (pp. 757–64). Association for Computing Machinery. https://doi.org/10.1145/1476589.1476686

Tate. (2017, June 26). Virtual reality comes to Tate Modern for Modigliani [Press release]. https://www.tate.org.uk/press/press-releases/virtual-reality-comes-tate-modern-modigliani

Thiel, T. (n.d.). *Land of cloud*. https://tamikothiel.com/land-of-cloud/index.html

Tykhonova, O., & Widmann, S. (Eds.). (2021). *Museum Innovation Barometer 2021*. Museum Innovation Barometer. https://cultureactioneurope.org/knowledge/museum-innovation-barometer-2021/museum-innovation-barometer-2021/

Ungerleider, N. (2016, April 5). *Google's Tilt Brush is the first great VR app*. Fast Company. https://www.fastcompany.com/3056668/googles-tilt-brush-is-the-first-great-vr-app

Virtual Reality Society. (2017, June 2). *History of virtual reality*. https://www.vrs.org.uk/virtual-reality/history.html

Wagner, K. (2016, March 24). *Two years later: Facebook's Oculus acquisition has changed virtual reality forever*. Vox. https://www.vox.com/2016/3/24/11587234/two-years-later-facebooks-oculus-acquisition-has-changed-virtual

Williams, J. (2023). Virtual reality demographics: 57 user facts & numbers [2023]. Techpenny. https://techpenny.com/virtual-reality-demographics-57-user-facts-numbers-2023/

Wu, K. (2021). Uglykiki. Retrieved from https://uglykiki.com/

Zimmerman, G. W., & Eber, D. E. (2001). When worlds collide!: An interdisciplinary course in virtual-reality art. In *SIGCSE '01: Proceedings of the thirty-second SIGCSE technical symposium on Computer Science Education* (pp. 75–79). Association for Computing Machinery. https://doi.org/10.1145/364447.364545

10. APPENDIX

Interview Question 01:

INTERVIEWEE		**CONDUCTED BY**	Lam Choon Khee / Prof Benjamin Seide
INTERVIEW DATE		**INTERVIEW START TIME**	**INTERVIEW END TIME**
THESIS TITLE	EXPLORING VIRTUAL REALITY PAINTING TECHNOLOGY AND ITS POTENTIAL FOR ARTISTIC PURPOSES	**OBJECTIVE**	Explore how virtual reality can affect the artistic process. This research includes the investigation of virtual reality content and technology.
INTERVIEWEE PROFILE			

INTRODUCTION

The interview explores the artists' experiences and the potential use of virtual reality painting technology for their artistic purposes.

INTERVIEW QUESTIONS

	QUESTION	NOTE
01	As an internationally known visual artist working in virtual reality art, when and how did you first encounter virtual reality to create artwork?	

02	How has virtual reality painting technology impacted your artistic processes?	
03	What are the features of virtual reality that attract you to use it in your creative process?	
04	Virtual Reality Painting Application enables users to paint visual imagery in 3D space using a handheld controller that mimics the painting movement using a range of tools, brushes, and paint effects. Describe your experience.	
05	What are the other mediums that you have worked on before using virtual reality? How is virtual reality different from working in other mediums? Have the artistic process and viewing experience significantly impacted your creative processes? What challenges and difficulties have you faced when using virtual reality in your work?	
06	Exploring an artwork in a 3D virtual space can be seen as a more intuitive and natural way compared to the experience of a linear medium (Engasser, 2016). However, Tara Chittenden (2018) believes that there is some limitation of virtual reality painting can do as it "challenges the conventional frame of a painting and brings into question the nature of boundaries in the act and object of painting." What is your opinion on this?	
07	You are one of the selected artists as part of the Artist-in-Residence programme. What is the potential and possibilities of the virtual reality painting tool that can be further developed? Could you walk us through your creative process when working on your artwork using virtual reality? What was your inspiration for that and some of your other VR creations?	
08	What are the limitations of virtual reality painting technology that impacted you and your creative processes? Can virtual reality's usability utilize your potential as an artist? What lessons have you learned from creating in virtual reality that you would	

	share?	
09	Do you have any advice for other virtual reality creators?	

NOTE
Additional note for reference.

Interview Question 02 (Participatory Research):

	QUESTION	NOTE
01	What is your role as an artist? Which other mediums did you use before virtual reality? How is virtual reality different from other mediums? Have the artistic process and viewing experience significantly impacted your creative processes? Could you walk us through your creative process when working on your artwork with virtual reality?	
02	What were the challenges and difficulties that you faced when using virtual reality in your work? How could they be improved? What are the potentials of virtual reality that could be further developed?	