Place as Palimpsest:

Traces to Enhance Placemaking in Virtual Environments

by

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Abstract

Virtual environments have emerged as dynamic and immersive spaces that foster diverse user interactions and experiences. In the process of the creation and evolution of virtual places, challenges arise about how to make a good place in virtual environments. The majority of existing virtual environments suffer from a notable lack of traces, which refers to the visible evidence of human presence and activities within the space. This element is vital for successful placemaking, drawing from our experiences in creating successful places in physical environments. Drawing inspiration from the metaphor of place as palimpsest, this thesis sets out to explore how the concept of traces can be introduced from physical environments to virtual environments to enhance placemaking, examining how traces of user actions and interactions influences the process and results of placemaking. I chose the Carnegie Mellon University Fence as the case site and created a virtual environment based on it to conduct a multiplayer cycle study to explore the effect of traces in virtual environments. I employed a mixed-method approach, combining quantitative analysis of user data with qualitative investigation through user interviews to measure the social presence, cultural presence and sense of place and the traces' effect on them. My findings highlight the transformative potential of the virtual traces, illustrating its role in enriching user experiences and promoting a more thoughtful and intentional approach to placemaking in virtual environments. As virtual environments continue to evolve and influence our lives, my work should be valuable for further exploration and design considerations in shaping meaningful virtual places.

Keywords: place, placemaking, virtual environments, traces, social presence, cultural presence, virtual reality

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1 INTRODUCTION

This chapter situates my work by introducing the concept of placemaking, proposes my research question about traces and placemaking in virtual environments and offers a clear understanding of the purpose, significance, and direction of the thesis.

The term “placemaking” originated in the 1960s in architecture and urban planning fields. Architects and urban planners sought to revitalize public spaces, enhance a city's image, and create tourist attractions through their efforts in place-making.[1] The values of place are in both the physical and social environment where the relationship is constructed.[2] Urban archaeologist Schofield argued that the process of place-making incorporated physical dimensions, social relation, symbolic meanings and subjective human experiences.[3] It is a process of creating and shaping a space with the aim to make it more attractive, functional, and meaningful for the people who used, are using or will use it.

In the physical environments where the concept originates from, placemaking can take different forms from the design of a city's public squares and parks, to the creation of unique storefronts in a downtown area and the placement of public art installations. Their common goal is to create meaningful quality places, which often is described as to create a sense of place. It’s true that various characteristics of a place will influence both the process of placemaking and the formation of a sense of place. As technologies advance, place as a concept is not just limited to application and description in traditional physical environments. Many emerging virtual environments like video games try to have their own placeness which means placemaking happens not only in the physical world but also the virtual world. Compared to the virtual world, the physical world is more capable of creating a sense of place because prior architects and urban planners have already set up useful guidelines and principles that later architects and designers need to follow.[4] Although researchers are exploring creating placeness in the virtual environment for different purposes and in different contexts, they face similar challenges when they want to create meaningful relationships between people and place. In a virtual environment, all the elements of the spaces can be easily reset by the system or users to revert to their

[1] Paquin, Alexandra Georgescu. "Public data art’s potential for digital placemaking." *Tourism and Heritage Journal* 1 (2019): 32-48.
[2] Friedmann, John. *Planning in the public domain: From knowledge to action*. Princeton University Press, 1987.
[3] Schofield, John, and Rosy Szymanski. "Sense of place in a changing world." *Local Heritage, Global Context*. Routledge, 2016. 19-30.
[4] Tan, B-K., and Stephen Lim Tsung Yee. "Place and placelessness in 3D online virtual world." (2010).

original states at the starting point.[5] This means that any changes, interactions, or modifications that occurred within it can be undone and discarded without leaving any traces. In contrast, physical environments have an independent persistence, where the changes made to the physical space are lasting and accumulate over time. This lack of independent persistence in virtual environments poses challenges in creating meaningful people-place relationships and building a strong sense of place.

In physical environments, the traces of past interactions and experiences are kept visible, and they contribute to the convey of history, culture and identity, and the formation of the attachment to a place. People feel a deeper connection to a physical place when they see the effects of their actions and the actions of others which is presented as a form of traces, leading to a sense of ownership and belonging. However, many existing virtual environments struggle with the lack of traces. To address this challenge, this thesis draws inspiration from the metaphor of place as palimpsest, a parchment or writing surface that bears traces of previous writings and explores the research question:

How can the elements of traces be introduced into virtual environments to enhance the process of virtual placemaking?

By examining how traces of user actions and interactions influence the placemaking process and outcomes, the study seeks to understand how virtual environments can emulate the sense of place that physical spaces evoke.

To investigate the impact of traces in virtual environments, the Carnegie Mellon University Fence serves as the chosen case site. This iconic structure has been adorned with various messages, artwork, and memorabilia over the years, making it a compelling subject for understanding the significance of traces in shaping a sense of place. Using this site as a foundation, a virtual environment is meticulously crafted. This virtual representation serves as the setting for a multiplayer cycle study, where users engage and interact within the digital space, leaving traces of their presence and actions. Employing a

[5] Hirsch, Linda, Ceenu George, and Andreas Butz. "Traces in virtual environments: a framework and exploration to conceptualize the design of social virtual environments." IEEE Transactions on Visualization and Computer Graphics 28.11 (2022): 3874-3884.

mixed-method approach, my research combines quantitative analysis of user data with qualitative investigations through user interviews. This comprehensive methodology enables a thorough examination of how the introduction of traces influences various aspects of the virtual environment, including social presence, cultural presence, and the formation of the sense of place.

The findings of the study reveal the transformative potential of virtual traces in fostering a more thoughtful and intentional approach to placemaking in virtual environments. The presence of traces, which mirror those found in physical spaces, contributes to a heightened sense of immersion and attachment to the digital environment. Users are more likely to feel a genuine connection to the virtual site when they perceive its history and cultural significance through traces left by themselves and others. Consequently, the research highlights the importance of incorporating traces into the design and development of virtual environments, as they play a vital role in creating meaningful and memorable user experiences.

As virtual environments continue to evolve and exert an increasing influence over our lives, this work holds valuable implications for further exploration and design considerations in shaping meaningful virtual places. Understanding how virtual traces impact user experiences can pave the way for the creation of more compelling and immersive digital spaces that evoke a sense of place and establish stronger relationships between users and virtual environments. The insights from this research contribute to the advancement of virtual placemaking, ultimately enhancing the quality and significance of interactions within virtual environments.

This thesis comprises five chapters. The first chapter situates my work and offers a clear understanding of the purpose, significance, and direction of the thesis. The second chapter introduces relevant concepts and definitions, conducts background research on placemaking both in physical environments and virtual environments, and discusses the challenges virtual environments face in placemaking. The background research and discussion serve as the foundation for subsequent hypothesis development in the third chapter. In the fourth chapter, the methods employed in this thesis are elaborated in detail.

The case study process is described in depth, including the introduction of the case site and the construction of virtual reality environments and study procedure to validate my hypothesis. The findings chapter documents the results of quantitative and qualitative analyses, along with the results and findings drawn from the user study. Finally, the concluding chapter highlights how the findings contribute to our understanding of placemaking in virtual environments, discusses the limitations of my work and suggests avenues for future research to build upon this work.

2 BACKGROUND

This chapter introduces relevant concepts and definitions, conducts background research on placemaking both in physical environments and virtual environments, and discusses the challenges virtual environments face in placemaking.

2.1 Elements of placemaking

Placemaking is a concept deeply rooted in the physical world development. Placemaking aims to improve the quality of spaces and promote a sense of place. The experiences and lessons learned from physical placemaking can inform the design and implementation of virtual placemaking initiatives. Understanding the successes and failures in the physical environment can guide decision-making in the virtual environments, allowing for more informed and effective practices.Virtual environments provide novel tools and possibilities that can complement or enhance traditional placemaking practices, but understanding the existing challenges in the physical world is critical for utilizing the full potential of virtual placemaking. Numerous researchers have identified key elements that contribute to successful placemaking. For example, architectural psychologist David Canter argued that the meaning of Place is defined by human action as much as by location and form and proposed a model of placemaking which consists of three components: (1)physical form; (2)actions and (3)conceptualisations. Based on this model, he divided the process of placemaking into three different stages: (1)designation of location; (2) the designation of action; and (3)the designation of place.[6] As the goal of placemaking, Canadian geographer Edward Relph relates the sense of place to people's identity of and with place which refers to its "persistent sameness and unity which allows that [place] to be differentiated from others".[7] Relph described it in terms of three components: (1)the place's physical setting; (2)its activities, situations and events; and (3)the individual and group meanings.[8]

[6] Canter, David. *The psychology of place*. Architectural Press, 1977.
[7] Relph, Edward. *Place and placelessness*. Vol. 67. London: Pion, 1976.
[8] Relph, Edward. "Classics in human geography revisited, place and placelessness." *Progress in Human Geography* 24.4 (2000): 613.

These two researchers share similar views on what are the key elements of placemaking, which lay a foundation framework for guiding placemaking in the virtual environments:

Key elements	By David Canter	By Edward Relph
Physical setting	Physical form	Physical setting
Human interactions	Actions	Activities, situations and events
Meanings	Conceptualisations	Individual and group meanings

Table: The three key elements for placemaking

(1)Physical setting: The physical attributes of a place, such as its architecture, design, spatial arrangement and built elements, play a crucial role in placemaking. These elements contribute to the overall character and identity of a place;

(2)Human interactions: The actions, behaviors, and social interactions that occur within a place, encompassing both planned and spontaneous activities.

(3)Meanings: The individual and group interpretations, perceptions, and attachments associated with a place. This includes the symbolic, historical, and emotional significance people attribute to the place.

2.2 Placemaking in the virtual world

By the early 1990s, there was a notable upswing in interest regarding the concept of 'place' in the context of digital environments. This appropriation was driven by two technology developments, the pervasive rise of the Internet and real-time interaction with

multimedia data.[9] Benefiting from them, the concept of placemaking began to take shape as a structuring idea in the context of interactive digital technologies in the early 1990s.

Making places in virtual environments involves the organization and manipulation of various elements such as virtual landscapes, architecture, visual aesthetics, and interactive features to establish distinct virtual "places". These places can range from virtual towns to gaming environments and virtual reality platforms. Nevertheless, designers of virtual environments often encounter a challenge in the absence of well-established guidelines or frameworks that assist them in comprehending and implementing appropriate placemaking principles within the virtual environments. We can carry over spatial patterns or patterns of behavior learnt from the physical world to the virtual world by designing and building them to share the same or similar appearances and affordances for action and interaction that places in the physical world exhibit. Learning from a place in the physical world and designing or building related elements in a similar way will help us make better places in virtual environments.[10]

In this thesis, I take as a premise the idea that designing places in the virtual world can incorporate the elements and concepts which have been used in placemaking in the physical world. Many designers and researchers started considering the degree of correspondence between the real and physical worlds as a measure of successful virtual environments.[11] For example, architecture researchers Yehuda Kalay and John Marx use a scale to categorize ‘cyberspace’ into: hyper reality; abstracted reality; hybrid cyberspace; hyper virtuality and proposed eight criteria of virtual placemaking: Places as setting for events; Places involve engagement with objects or people; Places provide relative location; Presence and location promote a sense of authenticity; Places must be

[9] Champion, Erik, and Bharat Dave. "Where is this place." *Proceedings of ACADIA 2002: Thresholds Between Physical and Virtual*. 2002.
[10] Abd Al-Rahman, Hamsa, and Mohammed Qasim Abdul Ghafoor. "Employing Virtual Reality for Place-making: Mimicking the Real World in the Virtual World." (2023).
[11] Champion, Erik, and Bharat Dave. "Where is this place." *Proceedings of ACADIA 2002: Thresholds Between Physical and Virtual*. 2002.

adaptable; Places afford a variety of experiences; Places offer the choice and control over transitions; and Places are memorable.[12]

There are also many researchers and writers who have proposed similar criteria and have been adding new criteria into the frame. For example, Tan Beng-Kiang and Stephen Lim Tsung Yee argue that Kalay and Marx's criteria can not cover all dimensions of a virtual place and add 4 new criteria including context, gestures, improvisation and graphical representation.[13] This is because electronic media, especially virtual reality, generates great freedom of choice as Bruce Mau's question "Now that we can do anything, what will we do?".[14] While an ever-evolving and expanding framework can be valuable, it fails to help in understanding and identifying the most crucial and essential features and criteria for placemaking in the virtual world. Champion proposed a matrix that correlates placemaking features to general aims of virtual environments.[15] I try to relate the categorization to the three key elements of placemaking and introduce the three types with some project examples:

(1) Visualization-based environments

The visual environment stands as the first and prevalent form of 3D virtual environment. In its initial phase, the process of visualization encompasses capturing, manipulating, and presenting 3D objects. With the progression of technology, the capability to traverse virtual space or landscapes was introduced. With current technology, we can accurately capture realistic details and simulate physical laws, allowing for the creation of digital environments that represent spatial characteristics. This type targets spatiality visualization and often with limited interactivity. People can move in the environment, walk around objects and switch between some preset viewpoints or cameras. In these

[12] Kalay, Yehuda E., and John Marx. "The role of place in cyberspace." *Proceedings Seventh International Conference on Virtual Systems and Multimedia*. IEEE, 2001.
[13] Tan, B-K., and Stephen Lim Tsung Yee. "Place and placelessness in 3D online virtual world." (2010).
[14] Mau, Bruce. *Bruce Mau-MC24: Bruce Mau's 24 principles for designing massive change in your life and work*. London: Phaidon Press Limited, 2020., 2020.
[15] Champion, Erik, and Bharat Dave. "Where is this place." *Proceedings of ACADIA 2002: Thresholds Between Physical and Virtual*. 2002.

visualization-based environments, environments create a three-dimensional environment according to related physical environments.

For example, Notre-Dame de Paris stands as an exemplary representation of a place steeped in history, culture, and architectural brilliance. This iconic landmark has transcended the ages, witnessing centuries of significant events and serving as a focal point for religious devotion and artistic inspiration. On April 15, 2019, the world witnessed the near-destruction of Notre-Dame Cathedral in a devastating fire. While the cathedral undergoes restoration and remains inaccessible to the public, Ubisoft provided a virtual environment named Notre-Dame de Paris: Journey Back in Time. It was based on a meticulously crafted 3D reconstitution of Notre-Dame de Paris, the result of 5000 hours of detailed graphic work guided by historians. Drawing from this acclaimed model, Ubisoft's virtual environment offers users an opportunity to explore the cathedral from multiple perspectives, some of which were previously inaccessible to the public.This virtual environment faithfully replicates every detail of the building and significant artifacts. Users can freely look around and take a few steps, admiring each perspective of the monument through the VR headset.



Figure: South façade and the nave of Notre-Dame in 2017, two years before the fire
Image source: https://en.wikipedia.org/wiki/Notre-Dame_de_Paris

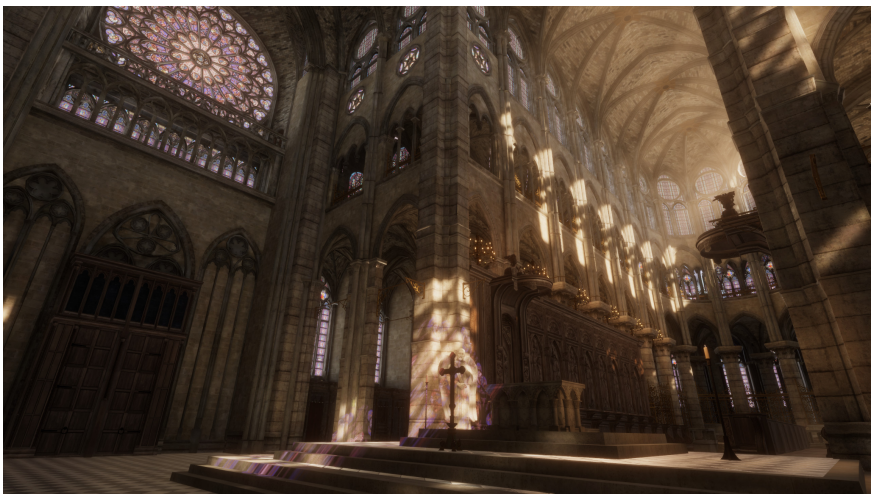


Figure: Screenshot in Notre-Dame de Paris: Journey Back in Time
Image source: https://steamdb.info/app/1341280/

This particular type of virtual environment aims to recreate the physical setting through its focus on replicating spatial characteristics and visual details found in the real world. The recent advancements in scanning technology, characterized by high levels of accuracy and extensive scale, have brought forth important implications regarding the representation of place in digital models. With advancements in virtual environments, it is now possible to incorporate realistic scanned artifacts alongside textures derived from the real world. The focus on realism in virtual environments generates a repository of visually represented objects and brings more and better visualization-based virtual environments. It primarily showcases static additions to the environment through computer-generated visualizations, but it overlooks environmental changes that occur over time and lacks interactivity.[16] While users can often manipulate the view and orientation in certain ways, the environment itself lacks true interactivity as it does not impact or allow users to modify their actions. Visualization-based environments are more like finished products: they appear similar and consistent in appearance to the physical environment but remain static and don't manage to affect or be affected by users. Their focus and advancement in realistic visualizing sometimes distract us from capturing a

[16] Eiteljorg, Harrison. "Photorealistic visualizations may be too good." *CSA Newsletter* 11.2 (1998): 1-4.

sense of place.[17] One of the primary challenges arises from the understanding that place is not a static and unchanging entity; rather, it encompasses a dynamic assortment of interpretations, actions, intentions, and beliefs.

(2) Activity-based environments

This type of environment allows activity to happen. Rather than simple direct visualization of the target, it goes beyond navigation and offers activity-based interaction, enabling a more immersive experience. Users can engage in tasks, make decisions, and navigate within the environment. This type of virtual environment is exemplified by computer games, which provide interactive and engaging experiences. “Activity-based environments are the most commercially successful type of virtual environment.”[18]

An exemplary illustration of such a virtual environment is the project called Discover Babylon, created collaboratively by a project team from Carnegie Mellon University's Entertainment Technology Center, the Federation of American Scientists, and the Walters Art Museum. The primary aim of this project was to engage "non-traditional museum visitors" by utilizing various platforms. It was designed as both a museum kiosk project and a PC game that could be enjoyed from the comfort of one's home.

[17] Laurel, Brenda, Rachel Strickland, and Rob Tow. "Placeholder: Landscape and narrative in virtual environments." *Acm Siggraph Computer Graphics* 28.2 (1994): 118-126.
[18] Champion, Erik, and Bharat Dave. "Where is this place." *Proceedings of ACADIA 2002: Thresholds Between Physical and Virtual*. 2002.



Figure: Screenshots in Discover Babylon
Image source: https://www.etc.cmu.edu/projects/i4i/index.html

The game transports players back in time to a Neo-Assyrian palace, immersing them in ancient Mesopotamia. The interface incorporates a camera with a limited battery life, which acts as a time constraint. The objective is to capture as many artifacts as possible using the camera before the batteries run out. Upon a successful capture, an information popup box appears, providing concise and straightforward details about the artifact. These descriptions are intentionally designed to accommodate the limited time and cognitive capacity typically available to museum visitors.

Compared to the visualization-based, the activity-based environments are created around a core user activity or mechanics which are usually related to game mechanics design like Pacman or some simulator game. There are tasks to complete, navigation to guide, items with specific functionality to use and social agency. It offers a higher degree of interaction, but users are always asked or guided to act through a series of tasks for an understandable goal (such as “go somewhere” or “get something”). But placemaking is not solely about designing spaces for specific activities. Emotional and social factors play a crucial role in shaping people's attachment and sense of belonging to a place. Activity-based environments are more like an artificial environment with preset conditioning for a specific activity. They might struggle to cater to individual preferences or adapt to users' unique needs. In these virtual environments, the place primarily serves as a static backdrop or location where objects are positioned. The environment acts as a mere container for the objects rather than an interactive and dynamic space where human activities can shape and transform the environment. As a result, the virtual place lacks the liveliness and adaptability that real-world spaces possess.

(3) Cultural ‘hermeneutic’ environments

Merely identifiable or activity-based virtual environments are not enough to create a virtual environment with a notion of a ‘place’. It is only when virtual places incorporate the notion of other people interacting with it, either similarly or differently from us, that a digital world truly takes shape. Drawing inspiration from Heidegger's concept of "worlding," a hermeneutic environment emerges. In this environment, individuals can

personalize their experiences and communicate their unique perceptions through artifacts. The more we can express our cultural communication and modify our surroundings in an authentic and unselfconscious manner, the more this environment transforms into a place.

"A hermeneutic environment requires the ability to personalize and communicate individual perceptions through artifacts, and the more deeply this cultural communication can be unselfconsciously expressed through our modification of our surroundings, the more this environment becomes a dwelling, a home, a place."[19]

There are seldom existing projects that can be viewed as a fully cultural 'hermeneutic' environment. But some elements can be found in the platform Second Life. Second Life is a digital platform where users can create avatars, build virtual spaces and interact with others. It offers a unique and immersive experience for socializing, exploring, and expressing oneself through user-driven content. American anthropologist Tom Boellstorff conducted more than two years of fieldwork in Second Life. He viewed the platform as a "virtual stage", what a hermeneutic environment should be. He suggested that placemaking is foundational to virtual worlds and residents in Second Life are preoccupied with some places even though they are only virtual.[20] The observation and findings of Boellstorff proved that present technologies have the potential to create the third type of virtual environments for placemaking.

The initial type of environment provides us with spatial presence, enabling visualization of objects and surroundings. The second type establishes a backdrop that facilitates actions and interactions. The third type allows us to perceive and comprehend the identity and intentions of others through the modification and personalization of the environment. It also allows us to express our own identity and intentions to others in a similar manner. The first and the second types in categorization cover most virtual environments people

[19] Champion, Erik. "Space and Place in Cyberspace." *Playing with the Past: Into the Future*. Cham: Springer International Publishing, 2023. 35-69.
[20] Boellstorff, Tom. *Coming of age in Second Life: An anthropologist explores the virtually human*. Princeton University Press, 2015.

have built with different focus, but as Champion argued, the third type is the most difficult to create.[21]

2.3 Challenges

2.3.1 Place as palimpsest

Place records traces of people and becomes a ‘trace’ museum. In terms of cultural hermeneutic environments, which is also defined as a culturally identifiable environment, “each place can be regarded as a palimpsest”.[22] The term "palimpsest" originally referred to a manuscript or parchment that had been written on, erased, and then written on again. The metaphorical understanding of a place as a palimpsest emphasizes the multiple and overlapping narratives, memories, and experiences that have shaped it, leaving traces and imprints on its physical and social fabric. It recognizes that a place is not a static entity, but rather a dynamic and ever-evolving space that bears the imprints of past events, activities, and cultural practices. Just as a palimpsest reveals glimpses of previous writings beneath the surface, a place as a palimpsest holds remnants of its past, visible in its architecture, landmarks, artifacts, and intangible elements such as stories and traditions. These layers contribute to the overall identity and character of a place, creating a rich tapestry of interconnected histories and meanings.

According to British social scientist and geographer Doreen Massey, places serve as a reflection of social processes.[23] In this context, a place represents a cultural setting that facilitates cultural interactions over time and in a specific location. Another British geographer, Mike Crang, argues that spaces evolve into places as they accumulate layers of meaning and significance through time.[24] The concept of a place as a palimpsest becomes essential when aiming to create culturally recognizable environments within

[21] Champion, Erik. "Space and Place in Cyberspace." *Playing with the Past: Into the Future*. Cham: Springer International Publishing, 2023. 35-69.
[22] Marvell, Alan, and David Simm. "Unravelling the geographical palimpsest through fieldwork: discovering a sense of place." *Geography* 101.3 (2016): 125-136.
[23] Massey, Doreen. *Space, place and gender*. John Wiley & Sons, 2013.
[24] Crang, Mike. *Cultural geography*. Routledge, 2013.

virtual spaces. A virtual environment should allow users to write and edit it, enabling them to leave their mark. In literature, we observe how specific places acquire a unique sense of identity through their historical use and the activities that take place within them. Places can be marked and recorded, preserving signs of their past utilization, and any modifications made by users should persist. Places are artifacts, as they often carry traces of past events. To embody these characteristics, virtual environments must record past events and remember ongoing activities, ensuring a sense of continuity and history within the virtual space.

2.3.2 The lack of trace

In most virtual environments that can be classed into the virtualization-based and activity-based environments, objects are simulated as static three-dimensional objects rather than objects in use, with traces of usage and interactivities and the place serves as a locator rather than a malleable container of human activities. However, cultural geographers argue that places should go beyond this function and evoke associations with past events while also stimulating future tasks and engagements and our understanding of reality is shaped by cultural and social constructs rather than being an inherent and objective truth.[25] Furthermore, a significant limitation of numerous scientifically precise virtual environments is their inability to retain a record of interaction history. In a truly interactive environment, the actions and choices made by visitors have an impact and shape the experience. However, many virtual environments fail to capture and store the traces of these interactions. While visitors in virtual environments may have the ability to modify certain elements of the environment, the virtual setting typically lacks the capability to "remember" the visitors themselves, including their paths, actions, and discoveries. In other words, the virtual environment often lacks a persistent memory of individual user interactions. The absence of such memory limits the personalization and long-term impact of user experiences within the virtual space.

[25] Peschl, Markus, and Alexander Riegler. "Virtual science. Virtuality and knowledge acquisition in science and cognition." *Virtual Reality. Cognitive Foundations, Technological Issues & Philosophical Implications*. Peter Lang, 2001. 9-32.

In virtual environments, the absence of traces limits the ability to convey a sense of history, usage patterns, and cultural significance. Without traces, virtual spaces may feel sterile, lacking the depth and richness that comes from the accumulation of human interactions over time. This absence can make it challenging to establish a cultural identity or create meaningful connections to specific traditions, customs, or narratives. Besides, when users are unable to modify the virtual environment or leave their own traces, it diminishes their sense of agency and ownership over the space. They may feel like passive observers rather than active contributors to the creation and evolution of the virtual place. Without the ability to leave their mark or influence the environment, users may find it challenging to develop a deep connection or emotional investment in the virtual space. Places in virtual environments should elicit a sense of history, triggering connections to previous experiences, and inspire users to envision future actions or interactions within that space. By imbuing virtual places with a deeper sense of meaning and purpose, they can foster a more immersive and engaging user experience.

3 HYPOTHESIS

This chapter will discuss the effect and role of traces in environments and develop my hypothesis to be verified on the foundation of analysis of trace-like elements in related works and projects.

3.1 Traces in environments

In this context, "traces" refer to tangible or visible evidence of activities, interactions, or history within both physical and virtual environments. These traces can manifest as marks, signs, or remnants that indicate past events, actions, or experiences. In physical environments, traces of prior human interaction or use play a crucial role in creating meaningful connections between people and places, ultimately contributing to placemaking and encouraging long-term visits. For example, a worn path on grass can provide residence for community connections and symbolizes trust.[26] The statue of John Harvard with bright toes shows the place's tradition of rubbing the toe of John Harvard's left shoe for luck. The traces in environments provide historical records of user interactions and behavioral patterns within a specific context.



Figure: A well-worn path of trust
Image source: https://firststop.org/half-a-mile-away-a-well-worn-path-of-trust/

[26] https://firststop.org/half-a-mile-away-a-well-worn-path-of-trust/



Figure: Statue of John Harvard
Image source: https://en.wikipedia.org/wiki/Statue_of_John_Harvard

Traces signify repeated use of social environments and have the power to transform artificially defined spaces into vibrant and social places. Moreover, these traces act as tangible evidence of time and transience, prompting users to reflect on and establish connections with their prior knowledge and cultural customs.[27] It is important to note that the interpretation and perception of traces by users are context-dependent and influenced by factors such as location, time, interaction, user background, and the material or object embodying the trace. From influencing behavior and social interactions to affecting emotions and perceptions, traces shape how individuals use and interact with the spaces around them. Some research discusses how traces or cues in the environment will affect users' decision making in some specific context.[28] thAs technologies grow increasingly intricate, traces' functions are often concealed to enhance usability. Nevertheless, this concealment results in a diminished understanding of their

[27] van Dijk, Jelle. "Creating traces, sharing insight: explorations in embodied cognition design." (2013).
[28] Albarrak, Luluah, Oussama Metatla, and Anne Roudaut. "(don't) mind the step: Investigating the effect of digital social cues on navigation decisions." *Proceedings of the ACM on Human-Computer Interaction* 5.ISS (2021): 1-18

inner workings and the significance they hold in our daily lives.[29] When virtual environments born of digital technologies are created, the same problem needs to be solved.

3.2 Trace-like elements in virtual environments

There are some trace-like design elements in virtual environments, especially some game virtual environments. Using visual markers to guide and navigate users is one of the most common mechanic designs in game virtual environments However, these markers do not authentically represent the real traces of user interactions within the environment. Instead, they are static and unchanging designs that lack a direct connection to previous users' actions. These visualizations are often independent of specific user interactions and are instead integrated with system-generated or preset features, aiming to create effects resembling genuine usage traces. While these visualizations may evoke a sense of authenticity and simulate the presence of usage traces, they do not directly reflect the individual actions or interactions of previous users within the environment. For instance, in Diablo 3 (2012), they are integrated into the virtual map scroll the player holds to set a destination and guide players in a specific direction.

[29] Robbins, Holly, Elisa Giaccardi, and Elvin Karana. "Traces as an approach to design for focal things and practices." *Proceedings of the 9th Nordic Conference on Human-Computer Interaction*. 2016.

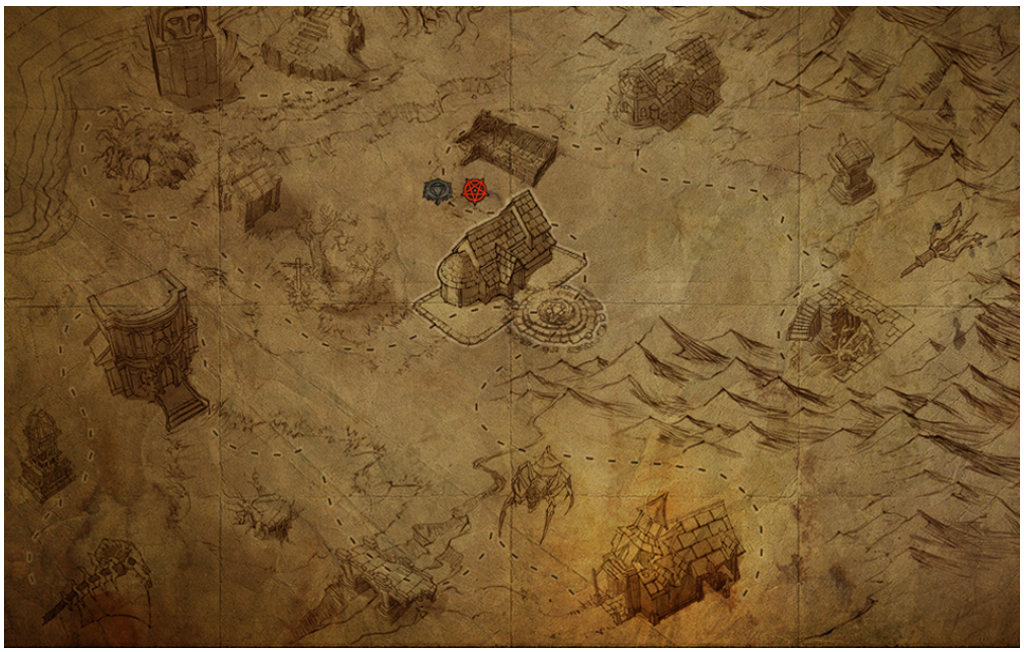


Figure: Traces on the map to navigate player in Diablo 3
Image source:
https://eu.diablo3.blizzard.com/en-us/game/guide/gameplay/world

There are several design features in games that resemble the concept of traces and emerge from players' actual interactions within the game. For instance, in World of Warcraft (2004), players can leave visual marks in the environment to communicate asynchronously, such as directing teammates or facilitating team cooperation.[30] These marks are purely visual and lack a physical presence within the game world. Similarly, in Dark Souls (2011), players can engrave messages on the ground using special items to convey messages to other players; in No Man's Sky (2016), players have the ability to construct communication stations that hold messages for other players to read when they visit the location; in Sky: Children of the Light (2019), players can leave messages as well in stone/gem-like objects, also on environmental elements such as candles, etc.[31][32][33]

[30]https://wowhats.wordpress.com/2011/02/14/binding-raid-marks-and-world-markers/
[31]https://darksouls.fandom.com/wiki/Messages
[32]https://www.kotaku.com.au/2016/12/no-mans-sky-fans-are-starting-to-find-messages-left-by-other-players/
[33]https://voices.uchicago.edu/202003sosc20224/2020/07/09/communication-and-self-expression-in-sky-children-of-the-light/

These examples align with the concept of trace as they originate from genuine player interactions and behaviors, rather than being prearranged by designers or generated by the game system. However, they differ from the broader notion of "trace" in that they are intentionally placed and serve as direct communication clues, rather than being implicit and dynamically evolving traces that transform based on user attributes and intentions.

In recent years, more intricate trace-like mechanics have emerged in games. For instance, in Death Stranding (2021), players can construct infrastructure within the game world, enabling other players to navigate challenging terrain.[34] This allows players to learn about the environment through what has been built by previous players, rather than solely relying on explicit messages left behind.

[34]https://www.gamerswithglasses.com/features/infrastructure-connection-deathstranding

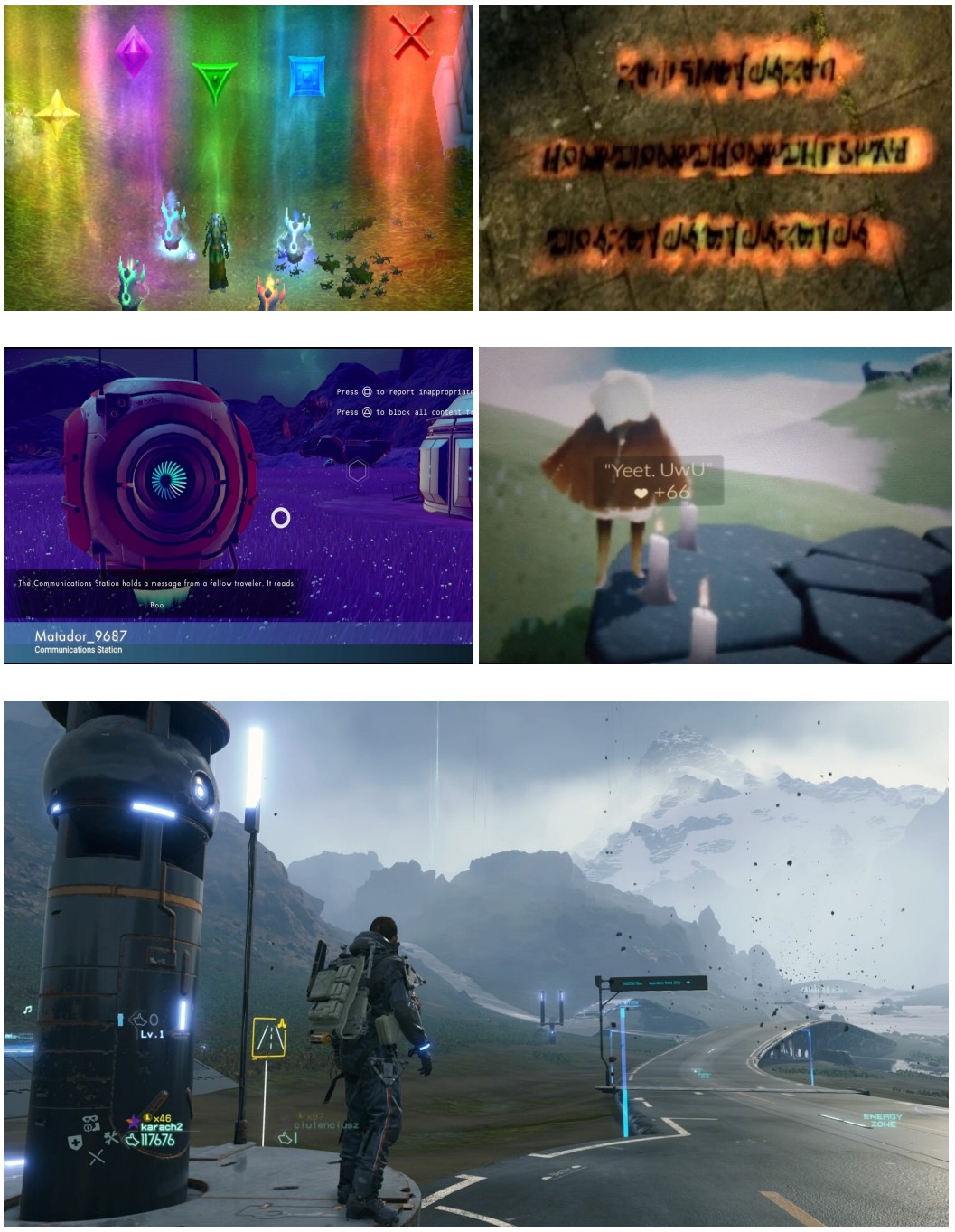


Figure: Trace-like elements in different games: World of Warcraft (2004) (left-top); Dark Souls (2011) (right-top); No Man's Sky (2016) (left-middle); Sky: Children of the Light (2019) (right-middle); and Death Stranding (2021) (bottom)
Image source: same as reference 26 - 30

While these examples provide a glimpse into trace-like elements in virtual environments, they highlight distinct differences between our use of the trace concept and existing trace-like features in certain games:

(1) Purpose and Function:
Traces in our physical life serve as historical records, providing valuable insights into the past and evolution of our environment. They are unintentional and often occur as a natural consequence of human activities over time. In contrast, trace-like elements in games, the artificial cues, feedback and indicators, are designed and implemented by game developers deliberately and purposefully. These elements are intentionally designed and programmed to provide players with information, guide their actions, or create better gaming experience within the game world and make the virtual world more interactive and immersive.

(2) Control:
Traces in our physical environment exist in the real world and are influenced by human interactions, the natural environment and real historical events. They are part of our everyday reality and contribute to the rich tapestry of place, society and culture. They are not under designers' or specific agents' control. Trace-like elements in games are confined to the game's rules and mechanics, serving the purpose of facilitating gameplay and storytelling. While they might mimic real-world elements, they are artificial constructs designed and crafted to be consistent with the game's theme and mechanics. They can not convey information from players more than what is expected or designed by game designers.

In summary, while traces in our physical life are genuine imprints of the past, trace-like elements in games are artificial constructs designed to enhance the gaming experience. Both serve different purposes and contexts, with traces in our physical life reflecting historical and cultural significance, while trace-like elements in games contribute to interactivity, immersion, and gameplay mechanics. The concept of traces in physical worlds can be incorporated into virtual environments to create a sense of cultural presence by evoking culture, traditions, and narratives. These traces can include visual

cues, symbols, or interactive elements that reflect the cultural identity of the place. Users can engage with these traces to explore and experience the cultural significance of the environment, fostering a deeper connection to the cultural presence within the virtual space. Furthermore, the presence of user-generated traces adds a layer of authenticity and social interaction to the virtual environment. It creates a sense of continuity and community, as users can observe and respond to the traces left by others. This fosters a shared sense of belonging and connection to the space.

Based on these discussions, I recognize that the interaction between people and place will create traces and people will have relationships to the place that are articulated by traces. I feel interested if the traces in a virtual environment will have a similar effect in the process of placemaking and if an understanding of designing traces tell us new things about virtual placemaking. I form the following two hypotheses to explore and evaluate the traces in virtual environments and design study to explore them:

Virtual environments with traces can help the formation and people's perception of sense of place in the process of placemaking.

4 METHODOLOGY

This chapter elaborates the methods employed in this thesis: the design probe and user study process is described including the introduction of the case site and the construction of virtual reality environments and study procedure to validate the hypothesis.

4.1 Case site: the CMU fence

To explore the traces' effect in virtual environments, I conduct a case user study to verify my hypotheses about use of traces in virtual environments and its effect on placemaking in virtual environments.

I choose CMU Fence as the site of my case study. The CMU Fence is a tradition at Carnegie Mellon University (CMU) in Pittsburgh, Pennsylvania. The tradition involves painting messages, slogans, and artwork on a fence that runs on the campus. The fence has been a platform for students to express their opinions, advertise events, celebrate achievements, and showcase their artistic talents by leaving traces since the early 1900s. This makes it a good example of placemaking, where a physical space is transformed into a meaningful and vibrant place by the people who use it. The tradition of painting the fence has created a unique sense of place and identity on the CMU campus.

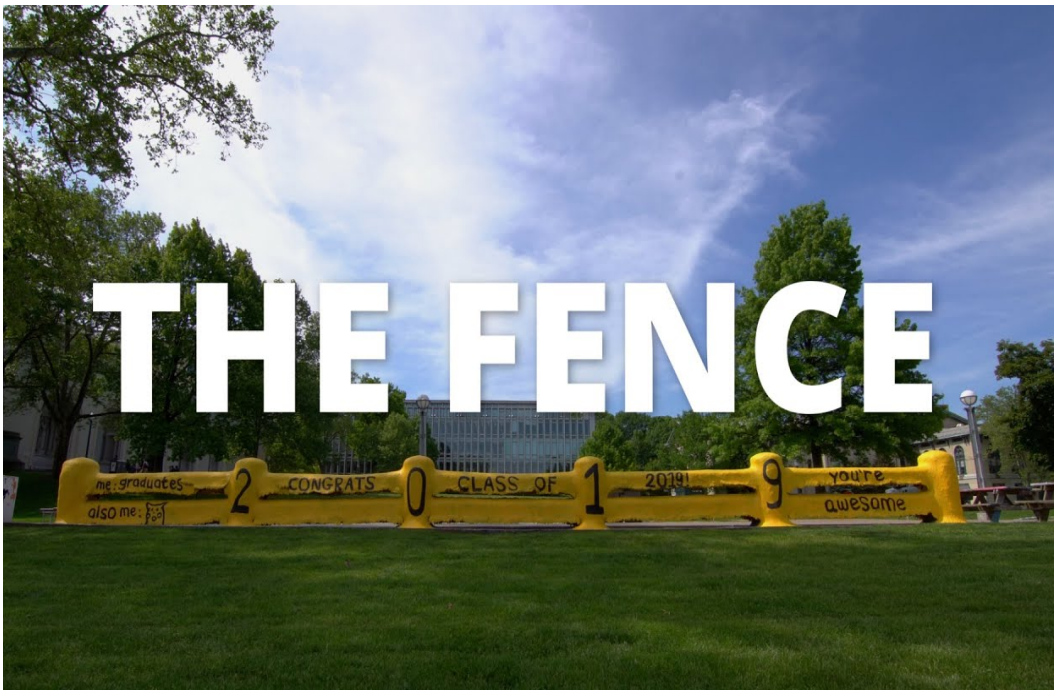


Figure: The Fence of Carnegie Mellon University
Image source: screenshot of https://www.youtube.com/watch?v=Wx-0UWxKixk

I chose it as my case site because it is an excellent example of "place as palimpsest" and an ideal case site for researching traces and placemaking due to its rich history and the way it has accumulated layers of paint and messages over the years. The messages on the Fence are always evolving. As new students arrive and others graduate, the traces on the Fence changes to reflect the interests and concerns of the current student body. It continually refreshes itself with new traces, but it never loses the imprint of past messages.

4.2 Study setup and procedure

4.2.1 Design probe

Design probes is a research method used in various fields, especially in HCI research and have been applied both to experimental research and business projects.[35] It is considered as a tool for capturing users' experience and behaviors as rich inspiration for researchers and designers.[36] To investigate the concept of traces in virtual environments and test my hypothesis, I developed a design probe using virtual reality technology. I conducted a user study that combined qualitative methods with quantitative data collection. For the study, I selected a physical placemaking site as a case site and created an asynchronous virtual reality environment accessible through a headset for the participants. The study employs a mixed-method approach, combining quantitative analysis of user data with qualitative investigation through user interviews. This approach allows me to unravel the intertwined relationship between traces and placemaking in virtual environments, shedding light on the profound interplay between user behavior and the resulting sense of place.

In this virtual environment, participants are fully immersed and can freely explore a digitally recreated version of the physical place. They can walk around, observe objects, and interact with specific objects in predefined ways, actively engaging in the

[35] Mattelmäki, Tuuli. *Design probes*. Aalto University, 2006.
[36] Wallace, Jayne, et al. "Making design probes work." Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. 2013.

placemaking process. Importantly, the participants' interactions and behaviors within the virtual environment generate traces that are retained within the virtual space.

After experiencing the virtual environment, I conducted semi-structured interviews with each participant. These interviews aimed to delve into the participants' subjective experiences and gain a deeper understanding of the perceptual and emotional effects of traces within virtual environments. Through these interviews, I sought to gather new insights and perspectives on the role and significance of traces in shaping user experiences in virtual environments.

4.2.2 Virtual environment setup

I captured the fence in 3D modeling using a photogrammetry technique. Photogrammetry is a technique used to create accurate three-dimensional (3D) models of objects or scenes from two-dimensional (2D) images. It can extract 3D information from a set of overlapping photographs taken from different angles of the target objects or scenes.[37] Photogrammetry is widely used in various fields, including archaeology, architecture, geology, and virtual reality experience.[38]

I collected close-range photographs of the fence by pointing the hand-held camera towards the structure of the fence at different angles to make sure there is enough overlap between every two close photos.

[37] Mikhail, Edward M., James S. Bethel, and J. Chris McGlone. *Introduction to modern photogrammetry*. John Wiley & Sons, 2001.
[38] Vajak, Denis, and Časlav Livada. "Combining photogrammetry, 3D modeling and real time information gathering for highly immersive VR experience." 2017 Zooming Innovation in Consumer Electronics International Conference (ZINC). IEEE, 2017.



Figure: Part of photos collected from the site

Once the images are imported, Metashape automatically identifies key features (key points or tie points) in each image. These features act as reference points to match corresponding points in other images.[39] Metashape uses the matched features to establish tie points between images. These tie points are used to align the images in the same coordinate system. This alignment process ensured accurate positioning and orientation of each photograph in relation to the others, laying the foundation for subsequent reconstruction steps.

Following the alignment of photos, Agisoft Metashape proceeded to generate a dense point cloud representation of the subject. This dense point cloud was created by identifying and correlating corresponding points in multiple photographs, ultimately producing a highly detailed and accurate 3D point cloud model. Building upon the dense point cloud, Agisoft Metashape further processed the data to generate a mesh

[39] https://www.agisoft.com/

representation of the subject. The mesh construction involved connecting the points in the point cloud to form a surface mesh, capturing the geometric shape and structure of the object or scene. Throughout the photogrammetry model generation process, various settings and parameters were carefully adjusted to optimize the quality and accuracy of the final model. These settings included controlling the level of detail, filtering options, and other parameters specific to the subject and desired output. The resulting photogrammetry model generated by Agisoft Metashape served as a valuable asset in this thesis, providing a detailed and realistic representation of the case of study.

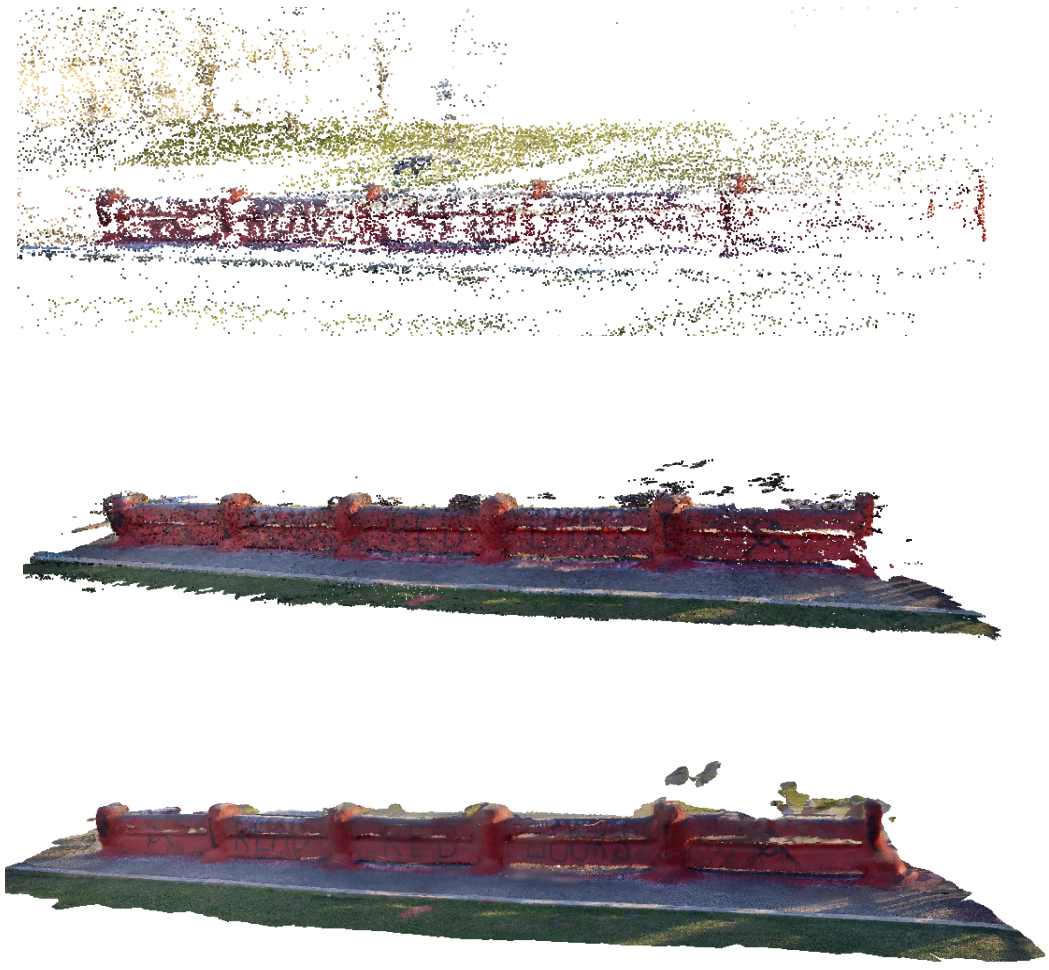


Figure: The photo modeling processing in Metashape: point cloud (top); dense point cloud (middle); and textured model (bottom)

I exported the .fbx 3D model with .png texture of the CMU fence from Metashap and imported it into Unity version 2021.3.14f1. The model in the scene was adapted into the proper size and proportion to make sure users feel comfortable in the VR environment with Oculus Quest 2 headset. The basic VR interaction, like headset tracking and controller interactions, was set in the default XR package offered by Unity engine.

4.2.3 Interaction Design

In the environment, users should view themselves as the visitor of the place to participate in the process of placemaking and feel the sense of place. Users wearing Oculus Quest 2 can look around in the first personal view to observe objects in the environment and walk around by moving the joystick of the left-hand controller.

Besides the common interaction setting of a three-dimensional VR environment, new interaction about traces is designed and implemented in my prototype. Users can paint with the right-hand controller: a raycast is cast by right hand as the painting indicator and painting can be triggered by pressing a button on the right-hand controller. There is a color palette attached to the left hand. Users can change the color they paint with by pointing their right-hand controller to a different position on the left-hand palette.

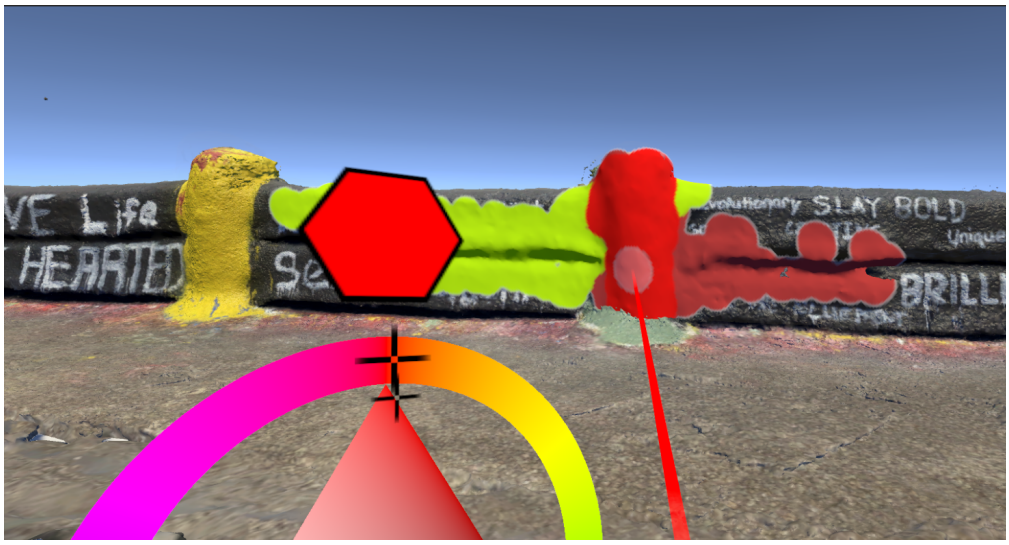


Figure: Interaction allowing users to leave traces

4.2.4 Study procedure

I designed a multiplayer cycle study(n = 3) based on the virtual environment of the CMU fence to explore the traces' effect on placemaking. To differentiate 3 participants, I use Participant A (PA), Participant B(PB) and Participant C(PC) to stand for them. In the whole series of studies, PA, PB and PC finished multiple studies at different times but in a certain order (PA - PB - PC). Studies were set up at times convenient for each participant. They were explained how the 3-round study would be conducted and what they were supposed to do before the first round. But PA, PB and PC were not told anything about the existence of other participants and their parts in this study.

The study consists of 3 rounds. In the first round, before entering the main environment for the first time, they entered the training environment to get familiar with the virtual environment and interaction like walking, turning around and painting until they felt confident in acting as they want in the virtual reality environment. Participants entered the virtual environment and no specific instruction was offered. They had as much time as they wanted to explore, interact and experience the place in any way they wanted in each sub-study. Once they confirmed that there were no more things they wanted to do in this round and were ready for filling questionnaires. They were given the questionnaires and completed them. PA was the first one to enter the main virtual environment and completed the questionnaire. The traces PA made in the virtual environment were kept for the next participant's study. Then PB was the second participant and PC was the third one to finish the same procedure.

The traces made in the first round were kept before the second round. In the second round, each participant had as much time as they wanted in the virtual environment. PA, PB and PC entered the virtual environment in the same order as the first round and completed the same questionnaire after each sub-study. The third round was conducted in the same way as the second round. In each sub-study, I noted their verbal responses while they were in the virtual environment to capture the immediate impression and effect of the respective environment. After the third round, I had a semi-structured post-study interview with each participant.

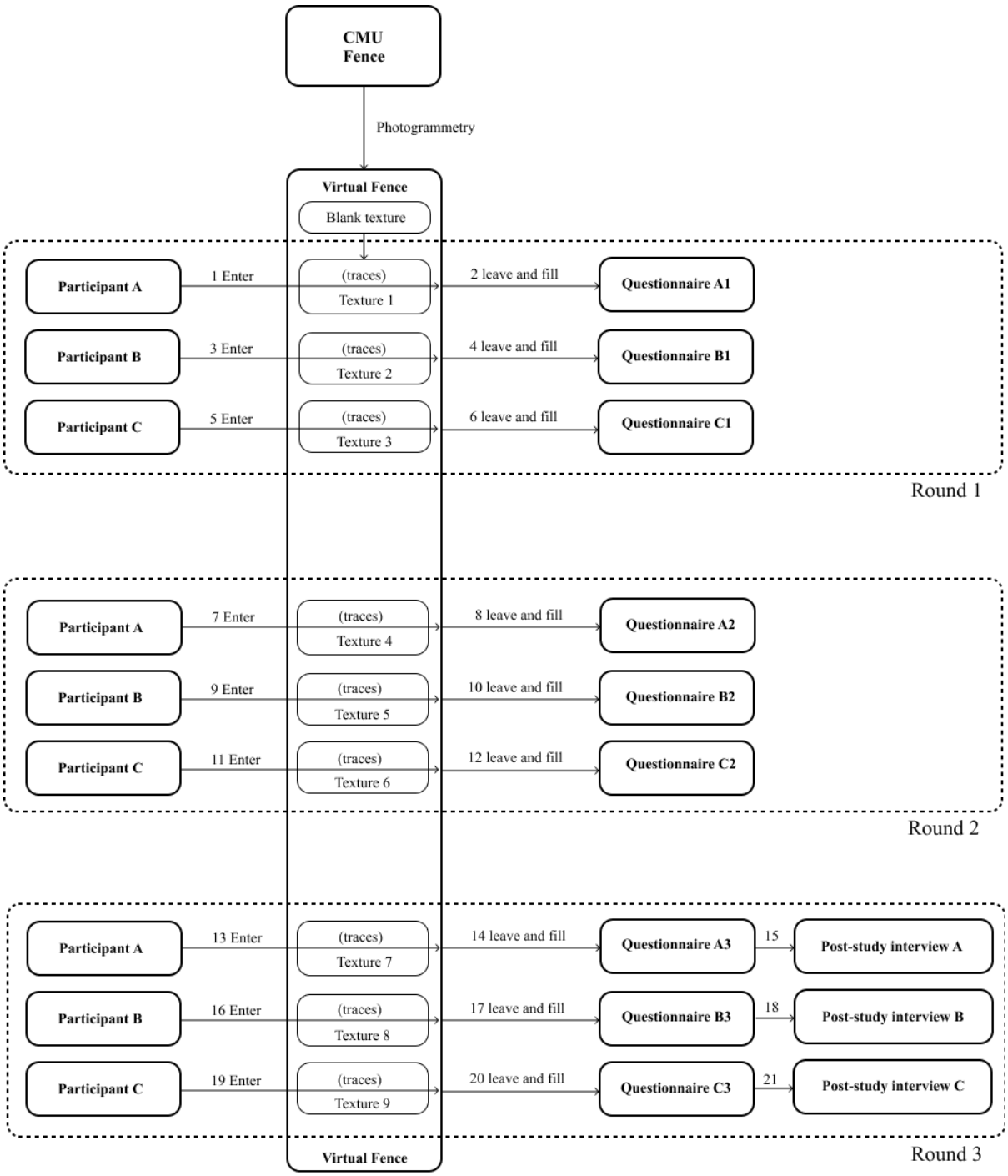


Figure: Study procedure diagram







Figure: 3 Participants in user study

4.2.5 Data collection

I tracked participants' social presence, cultural presence and general sense of place in the whole process of the study. I used a questionnaire to measure the social presence, cultural presence and sense of place. Questionnaires enable me to collect objective metrics, which allow for straightforward comparisons and quantitative measurements of participants' perceptions and experiences and changes in the process of placemaking. The questions are adapted from some prior research about social presence and cultural presence including Bailenson et al.'s questionnaire and Tost et al.'s evaluation of cultural presence.[40,41] The questionnaire includes 5 questions and users answer these questions on a 7-point scale (-3 = "Totally disagree"; 3 = "Totally agree"):

1. Do you have the perception that this place is used by other people as well?
2. Do you feel that other people are aware of your presence?
3. Do you think that the place is explorable and worth revisiting?
4. Can you feel the meaningfulness of the place, like activities, tasks and context?
5. Can you understand what other people are doing in this place?

Some discussions have proposed the use of ranking procedures to assess and measure the sense of place. I use Shamai's seven-degree scale to measure the sense of place users feel in the virtual environment.[42] The scale of sense of place encompasses the following 7 levels:

(0) Not having any sense of place - I do not sense the place at all.

(1) Knowledge of being located in a place - I can feel located in and recognize the place but do not feel that they are part of it.

(2) Belonging to a place - I have a feeling of belonging and togetherness to the place.

(3) Attachment to a place - I feel the meaning and personality of the place.

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[40] Bailenson, Jeremy N., et al. "Interpersonal distance in immersive virtual environments." *Personality and social psychology bulletin* 29.7 (2003): 819-833.

[41] Tost, Laia Pujol, and Erik Malcolm Champion. "A critical examination of presence applied to cultural heritage." *The 10th annual international workshop on presence*. 2007.

[42] Shamai, Shmuel. "Sense of place: An empirical measurement." *Geoforum* 22.3 (1991): 347-358.

(4) Identifying with the place goals - I recognize the goals of the place and are in conformity with them.

(5) Involvement in a place - I tend to take an active role in the place.

(6)Sacrifice for a place - I feel the deepest commitment to the place.

4.2.6 Semi-structured post-study interviews

Participants were asked questions concerning:

1. The process of placemaking
2. Differences between different rounds of study
3. The emotional experience change during the process

Such as:

- Have you noticed changes in the environments between different rounds of study? How do you feel about them?
- How do you feel now after 3 rounds of study? What's the difference from your first experience ?
- What do you think of your relationship with other participants?
- How did you determine what to do in this environment?
- How has your attitude towards this place changed?

The interviews (see Appendix 1 for details about the post-study interview) were structured to capture the participants' subjective feeling during the whole placemaking study process. Compared to the questionnaires, the post-study will focus more on how participants perceptions change as the study progresses. The interviews cover the participant's memory recall of behavior and interactions in different rounds of study. The changes of their perceptions and feelings can help me to understand how traces in the virtual environment can affect the process of virtual placemaking and people's perceptions of their social presence, cultural presence and sense of place. Post-study interviews allow participants to express their thoughts, emotions, and opinions in their own words, providing rich, subjective insights into their experiences. These qualitative insights can help validate and add depth to the quantitative results.

5 FINDINGS

This chapter states and discusses the results and findings from my design probe and how the findings contribute to our understanding of placemaking in virtual environments and suggests avenues for future research to build upon this work.

In my user study, the quantitative data collection by questionnaires after each study in each round and qualitative insights by observation and post-study interview are combined to inspire findings. By combining quantitative and qualitative data, I try to achieve a more comprehensive and robust understanding of the relationship between traces and placemaking in virtual environments. The quantitative data provide statistical evidence and general trends by the straightforward measurement of related concepts. Qualitative data from observation and post-study interviews offer a deeper understanding of participants' experiences and perceptions. This approach allows me to explore the nuances and complexities of the users' interactions with traces and their impact on placemaking. Through observation, you can capture real-time user behavior and interactions within the virtual environment, providing contextual insights that complement the questionnaire data. These contextual details help you interpret and understand the quantitative findings better.

In my thesis, I try to synthesize the results from them to present a cohesive and well-rounded exploration of the role of traces in enhancing placemaking within virtual environments. The two approaches together inspire a more complete narrative and support the validity of my findings.

5.1 Perception of social presence

Social presence refers to the “sense of being with others”.[43] When individuals feel the presence of others and are aware of being acknowledged in the virtual space, it creates a more immersive and authentic environment. This heightened sense of social connectedness leads to a stronger sense of place. The interaction with others and the shared experiences within the virtual community contribute to the formation of a virtual "place" with a distinct identity and social significance. In essence, social presence enriches placemaking by creating a vibrant and socially dynamic virtual environment.

[43] Biocca, Frank, Chad Harms, and Judee K. Burgoon. "Toward a more robust theory and measure of social presence: Review and suggested criteria." *Presence: Teleoperators & virtual environments* 12.5 (2003): 456-480.

5.1.1 Quantitative data

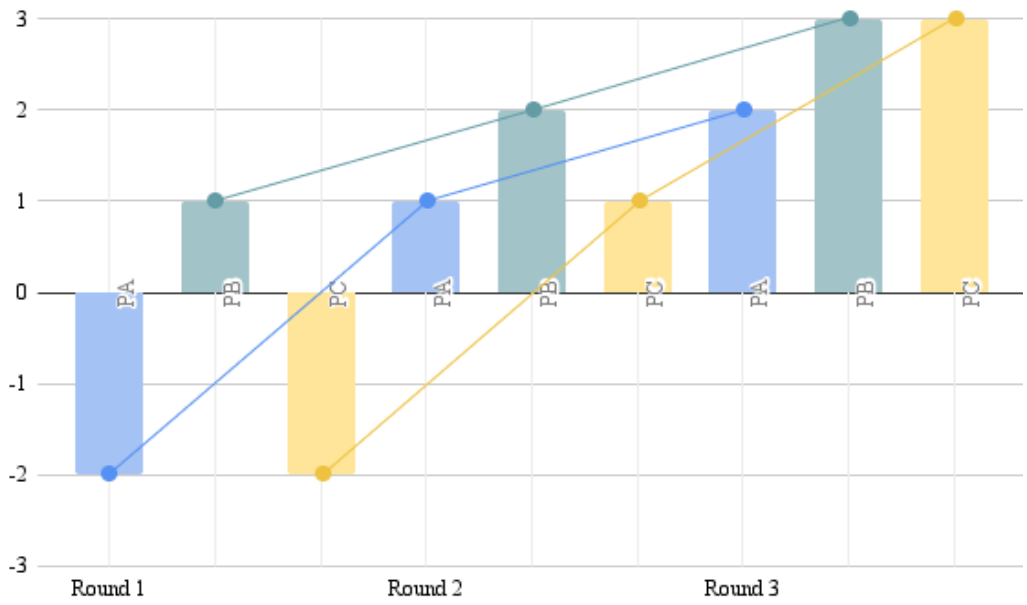


Figure: Do you have the perception that this place is used by other people as well? (-3 = “Totally disagree”; 3 = “Totally agree”)

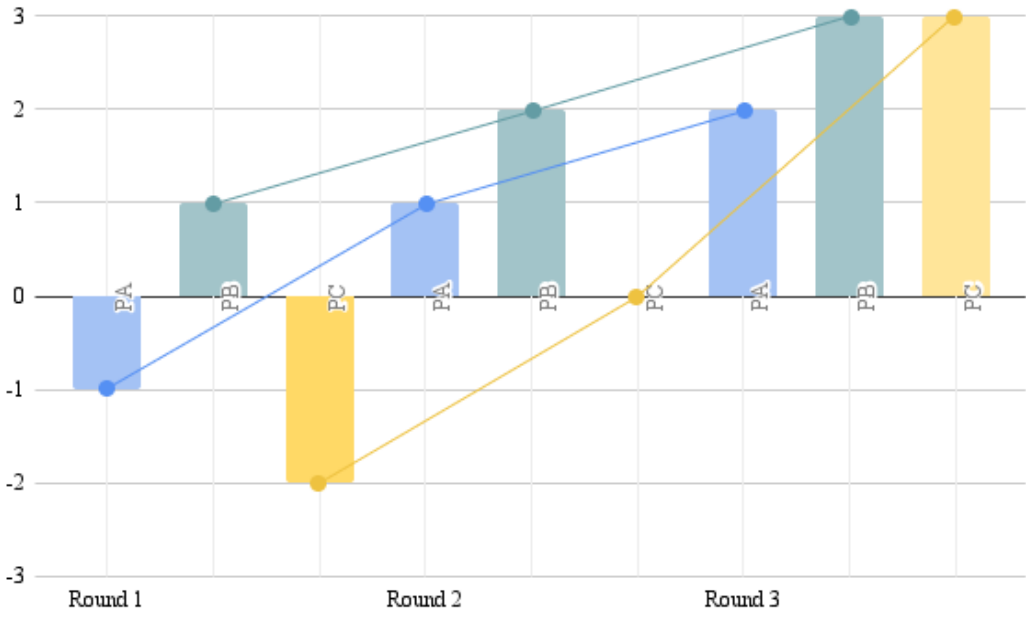


Figure: Do you feel that other people are aware of your presence? (-3 = “Totally disagree”; 3 = “Totally agree”)

The first question, "Do you have the perception that this place is used by other people as well?" aimed to assess participants' awareness of the presence of others in the virtual environment. "Do you feel that other people are aware of your presence?" sought to explore participants' sense of being acknowledged or recognized by other users in the virtual environment. In the first round when 3 participants were introduced into this virtual environment, their answers to both questions were closer to negative or neutral. In the second round, their answers shifted to be more positive and this positive attitude got enhanced in the third round. In the end of the third round study, the responses to this question were quite positive indicating that they did indeed perceive the presence of others in the virtual space and their own presence were perceived as well. By leaving traces in the virtual environment, participants' actions and contributions are perceived and acknowledged by others, contributing to a sense of social connectedness and the connectedness is continuously enhanced in the process.

5.1.2 Traces and social presence

PA talked about his first impression about the virtual environment, “The environment is very realistic, and the texture is good enough. But compared to a real place in the physical world, I feel a little lonely.” In their first visit to this virtual environment, they felt the lack of people or users of this place especially for PA who visited the virtual place without any traces. When PB was introduced to the virtual environment, he found that “Someone was here before because there are some paintings on the fence. … He might be a man because he wrote a girl’s name after ‘I’ and a heart pattern”, which means traces could serve as evidence of the existence and certain identities of other people. PC also made some similar judgments, “a Chinese came here because there is a Chinese word”. Traces left behind by other users can give a tangible sense of the presence of others in the virtual environment. These traces act as cues that reinforce the perception of co-presence, making the virtual space feel more lively and social.



Figure: the modification of PB on PA's trace

Traces left in the environment can provide valuable information about the presence and behaviors of others. This visibility can facilitate social interactions as users respond to or build upon the traces left by their peers, leading to more meaningful and dynamic engagements. For example, PB found a national flag and drew a Japanese flag beside it. After that, PC noticed the two flags but she thought the Japanese flag pattern was not good. So she polished the pattern left by others. Similarly, in PA's second round, he drew a new pattern and spent a lot of time polishing her drawing, likely to make it more clear

or aesthetically pleasing to others because “I want to make sure that others can understand”. PC also said “others should be able to understand … I don’t want it to be viewed as some other things” after modifying an area many times in the third round. This shows that participants understood the value of leaving traces that are easily interpretable by others, which can enhance communication. After realizing that others were using this place, PA started to pay attention to the quality of his traces to ensure the traces he left can be understood. He thought this contributed to a higher quality of their communication based on these traces. They started recognizing the significance of their traces being easily understandable by others and the impact of well-crafted traces on effective communication.

All participants used to cover traces they didn’t understand and add new traces to start a new topic. One of them said “maybe the people who drew it would be unhappy about that” when he covered a large area of traces on the virtual fence. This highlights the presence of a social aspect to the communication process within this group. Participants were not only focused on adding new content and understanding existing traces but also displayed consideration for the feelings or opinions of the individuals who had previously left those traces. The consideration of the original creators' feelings suggests that they valued the contributions made by others to the virtual fence. This respect for the work of others might lead to more collaborative and constructive communication practices.

5.2 Perception of cultural presence

Cultural presence is the representation and manifestation of diverse cultural elements within a particular environment, be it physical or virtual. Cultural presence plays a crucial role in shaping identities, fostering understanding, and promoting inclusivity within societies and digital spaces alike. Cultural presence can contribute to an enriching and harmonious coexistence which allows individuals from different backgrounds to appreciate and learn from each other's unique perspectives. The cultural presence emerges as a result of the dynamic interplay between people and their interactions with the physical environment. Cultural presence is an integral sign of shaping a unique cultural identity associated with a particular place.

5.2.1 Quantitative data

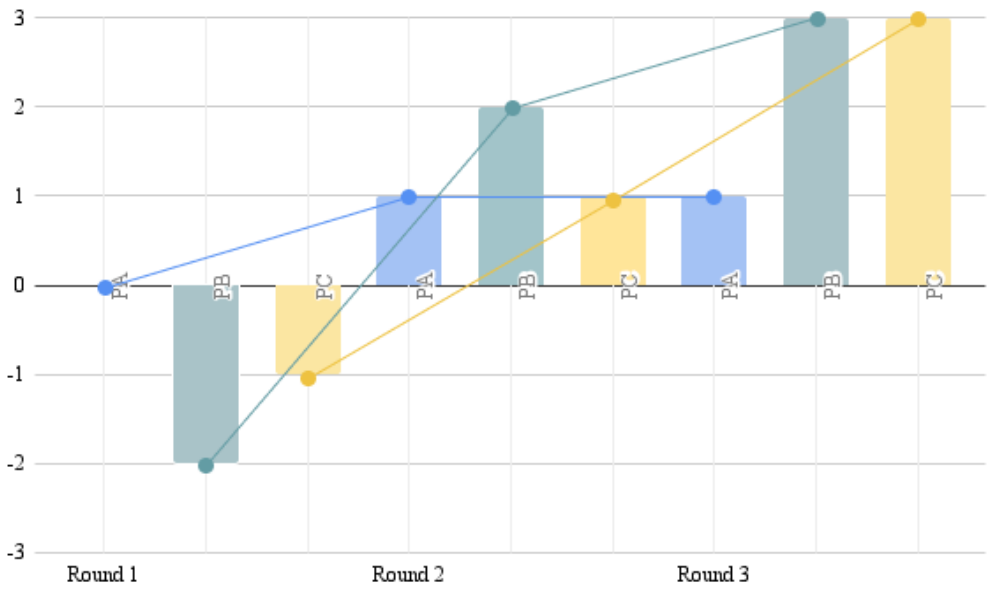


Figure: Do you think that the place is explorable and worth revisiting?
(-3 = “Totally disagree”; 3 = “Totally agree”)

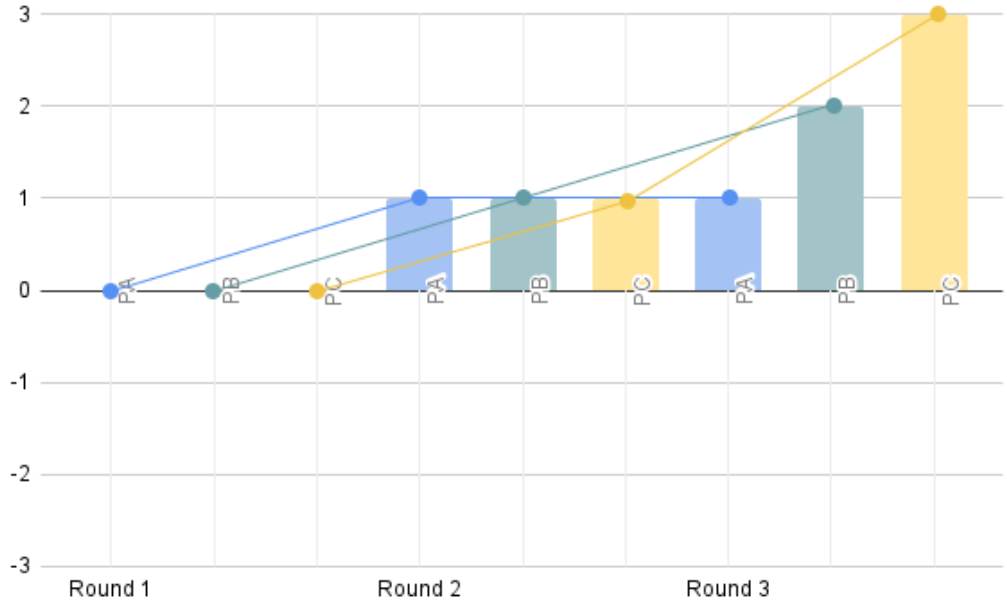


Figure: Can you feel the meaningfulness of the place, like activities, tasks and context?
(-3 = “Totally disagree”; 3 = “Totally agree”)

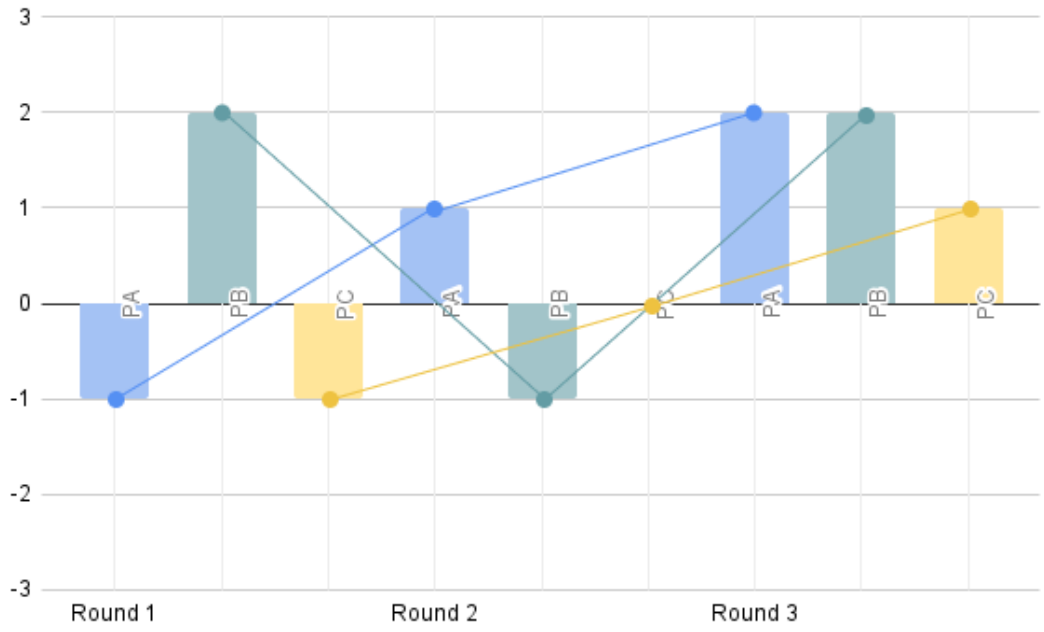


Figure: Can you understand what other people are doing in this place?
(-3 = "Totally disagree"; 3 = "Totally agree")

In the question "Do you think that the place is explorable and worth revisiting?", participants were asked to rate their perception of the virtual environment's explorability and revisiting potential. All 3 participants showed stronger willingness to explore and revisit this place after 3 rounds suggesting that the participants perceived the place as (somewhat/very) worth revisiting. For the question "Can you feel the meaningfulness of the place, like activities, tasks, and context?", participants expressed a positive connection to the context of the virtual environment and the results highlight the traces' success in eliciting a meaningful experience in virtual environments. But in the question "Can you understand what other people are doing in this place?", some differences between individuals are found in the whole process. PB gave a negative answer in the second round for this question which indicates that the process didn't enhance his understanding about other's actions and interaction in the virtual fence. The change might be due to the effect some traces in a certain context had on his perception which will be discussed later combined with my observation. The result might indicate that traces in the

virtual environment do not always benefit people's understanding of place-related or community culture. The effect is more context-specific and stage-specific. But his attitude turned positive after the third round. The process is related to the amount of traces, which might go through 3 stages: scarce traces to understand - enough traces to understand - too many traces to distract - filtered traces to form a stable understanding. I think the process can reflect some special relationship between traces and placemaking which triggers further discussion in 5.4.3.

5.2.2 Traces and cultural presence

In the first round of PA, he used to say "I don't know what to paint", so he decided to paint randomly from topic and contents. For example, he drew a heart and wrote a girl's name, content of which is quite private. He wrote "Asian" which stands for his personal identity and drew an Asian national flag pattern. He also wrote some English characters like "A" and "B". The topics, content and form of his traces spanned from private life to culture identity, from simple patterns to specific language, which are quite random. But when these traces were observed by PB, PB won't interact and respond to all the traces left. He ignored the more private topic and chose to respond to some traces he felt were more meaningful and participable. He followed the theme of the flag and drew a Japanese flag. When he noticed the English alphabet, he wrote a Chinese word which can be viewed as a kind of expression of his personal identity. Participants showed their tendency of leaving traces of the same forms but with their own personality or cultural preference. PB's selective response to specific traces suggests that certain types of content, such as cultural symbols and identity-related expressions, were perceived as more meaningful and participatory by PB. This indicates that cultural elements and symbols can play a significant role in facilitating meaningful interactions and engagement within the virtual environment. The interaction between PA and PB, where they responded to each other's cultural elements, demonstrates the potential for cross-cultural exchange and understanding in virtual placemaking. It indicates that virtual environments can foster interactions between individuals from different cultural backgrounds, promoting cultural diversity and mutual appreciation.

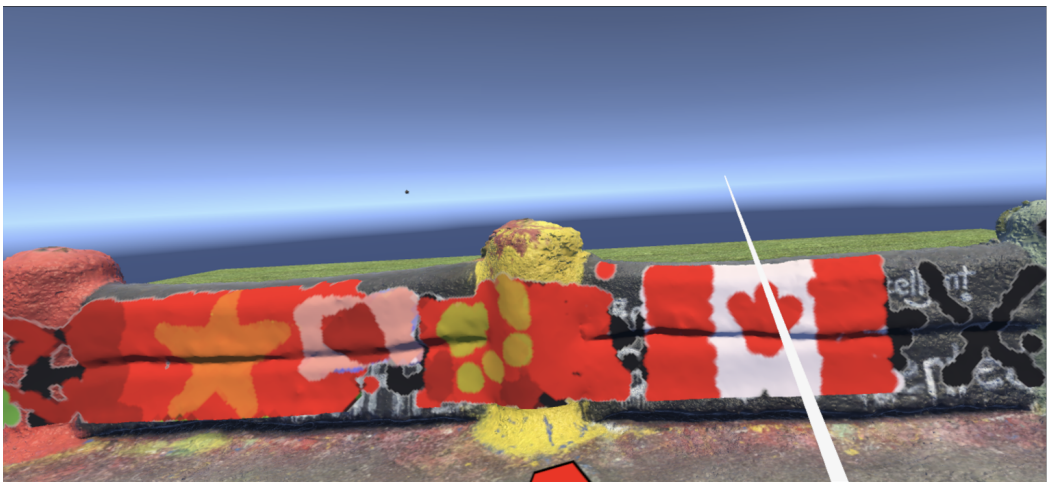


Figure: The trace cluster of flags



Figure: Chinese word trace by PB

The same process also happened across the second and the third round. PB wrote the name of the film "Barbie" and PA wrote another name of the film he liked, "Oppenheimer". PC recognized the two films and contributed two drawings about the plot of the two films on the fence. This indicates a level of cultural recognition and shared themes among the participants. The topic understood and admitted by different participants set the theme of the place and the process was achieved by the communication and interaction based on traces. Traces serve as a medium for meaningful

exchanges and collaborations within virtual environments, allowing participants to engage in shared creative endeavors and discussions. The series of traces gave the virtual fence a specific cultural identifiable vibe. The traces left by the participants, such as film names and related drawings, contributed to setting the theme and cultural identity of the virtual place. These traces acted as building blocks, creating a specific cultural identifiable vibe for the virtual fence. This highlights the role of traces in placemaking as elements that shape and define the cultural presence and atmosphere of virtual environments. The series of traces left by participants also contributed to the collaborative placemaking of the virtual fence. Through their interactions and contributions, participants collectively shaped the cultural presence and theme of the place. This finding highlights the participatory nature of placemaking in virtual environments and the potential for fostering a sense of shared ownership and belonging.

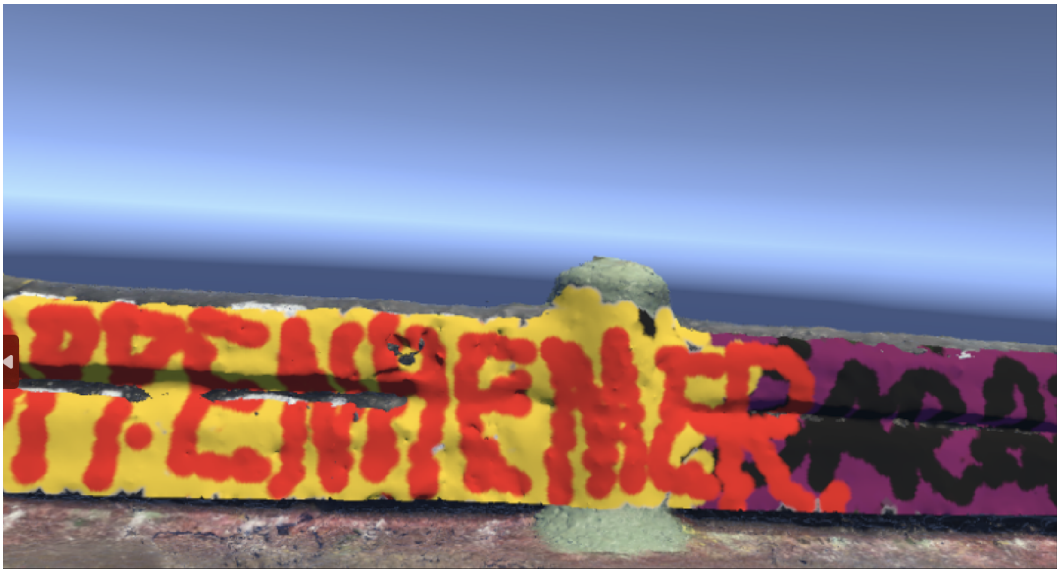


Figure: The name of films traces

PB gave a negative answer to the question "Can you understand what other people are doing in this place?" The second round of the virtual placemaking process indicates that not all traces in the virtual environment necessarily enhance people's understanding of the place-related or community culture. I think several factors can cause the gap:

Firstly, traces in virtual environments can be open to interpretation, and individuals may perceive and understand them differently. The interpretation of traces is subjective and can be influenced by personal experiences, cultural background, and individual preferences. Therefore, what one person finds meaningful or understandable in a trace might not be the same for others. Secondly, the impact of traces on understanding depends on their relevance to the overall context of the virtual environment. In the described scenario, PB's negative response might be due to certain traces being less relevant to his interests or cultural background. Traces that are contextually disconnected or unrelated to the virtual space may not contribute significantly to participants' understanding of the place or community culture. Thirdly, participants' level of engagement with the virtual environment and other traces can influence their ability to understand what others are doing. If someone is less interested or invested in the virtual place, they may not actively seek to understand or interpret others' actions.significantly to participants' understanding of the place or community culture.

5.3 Sense of place

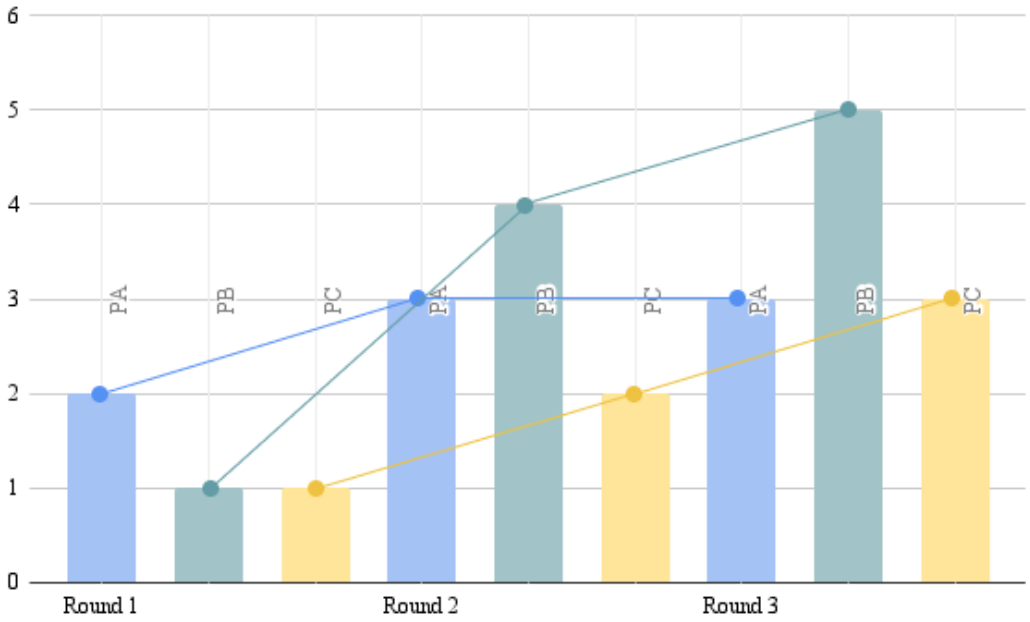


Figure: How do you feel about this place?
(0) Not having any sense of place; (1) Knowledge of being located in a place; (2) Belonging to a place; (3) Attachment to a place; (4) Identifying with the place goals; (5)Involvement in a place - I tend to take an active role in the place; (6)Sacrifice for a place - I feel the deepest commitment to the place. (4.2.4 for details)

The question's results reveal interesting changes in the participants' sense of place across the three rounds of virtual placemaking. There was a notable improvement in the participants' sense of place. As the virtual fence evolved through interactions and responses to the traces, a sense of belonging and connection to the place started to emerge. Their increased sense of place in the subsequent rounds suggests that the process of interacting with traces, recognizing shared themes, and contributing meaningfully led to a stronger attachment to the virtual environment. The finding that PB's sense of place surpassed that of the others might be attributed to his higher level of engagement and participation. His willingness to interact with various traces and respond to shared themes demonstrates a deeper commitment and investment in the virtual environment.

In conclusion, traces played a vital role in shaping participants' sense of place, fostering a collaborative atmosphere where individuals' expressions and cultural elements intertwined. The act of responding to each other's traces and recognizing shared themes created a shared understanding and a sense of belonging. Additionally, the participants'

increasing involvement and attachment to the virtual place demonstrate the effectiveness of traces in enhancing placemaking in virtual environments.

5.4 Discussion: traces and placemaking

5.4.1 Dynamic iteration of traces and shared meanings

In the whole study process, all participants were able to observe and interact with their own traces as well as others' traces in the virtual environment. They engaged in modifying, covering, or responding to existing traces, creating a dynamic process, which contributed to the evolution of the virtual place over time. As individuals interact with traces, they engage in a dynamic process, where new ideas and themes emerge from the continuous exchange and modification of content.

> *"I can find the traces left by myself and others, and how they affect each other and get iterated in the study … My decision about what traces to leave is greatly affected by what traces left by others. At first, I had little thoughts, but new motivation will be generated by others' traces."*

> *"I can judge if my traces were not understood by others according to whether they are interacted with. If not, I would give up some former traces and try to continue with some shared theme."*

This can result in the development of shared meanings and narratives within the virtual place. Besides the shared meaning, the participants also can convey their attitude by iterating traces.

> *"I will cover traces that are too out of date or complex to convey that I want to build some new communication and make my traces more noticeable by choosing a brighter color."*

Overall, it demonstrates the power of collaborative interactions and how shared meanings and narratives can be developed and evolved through dynamic exchanges among

participants. Traces serve as the bridges through which participants collaboratively shape the virtual place, creating shared meanings, narratives, and a sense of place. Through their traces, participants actively contribute to the process of placemaking and influence the overall character and atmosphere of the virtual environment.

5.4.2 Layers and complexity of traces

The evolution of the virtual fence with multiple layers of traces allowed for a richer and more diverse placemaking experience. The presence of multiple layers contributed to a sense of depth and complexity in the virtual environment.

> *"When I entered the environment in the third round, I don't remember what I did in the first and second rounds. But when I look at the traces again, they will remind me of some former experience in it."*

> *"At first, the fence was kind of boring. But now, the layers of traces on the fence bring more rich meanings. I feel the place is more playable."*

In summary, traces left behind act as reminders of past experiences. The accumulation of traces over time enriches the place, making it more engaging and enjoyable. Playability in the virtual environment is enhanced through the creation of a palimpsest-like experience, where the accumulation and interaction of traces generate a dynamic and engaging place for participants to explore and interact with over time.

5.4.3 Trace overload and filtering

As the layers and complexity increased in the placemaking process. The accumulation of traces resulted in a "trace" overload, meaning that the volume and intricacy of the traces became overwhelming or excessive. With an abundance of traces and interactions, participants might find it challenging to process and keep track of all the information. The cognitive load, or mental effort required to make sense of the traces, increases as more

layers and complexity are added. The richness and complexity of the traces might interfere with the clarity of the shared meanings and narratives. With too many traces, it becomes harder to discern the essential themes or messages. The overwhelming number of traces can reduce the overall playability of the virtual place. Participants might feel less engaged or discouraged from further interaction due to the burden of navigating through an overly complex environment. So some filtering mechanisms will be formed automatically.

> *"When I want to cover something, I will choose to cover the traces that didn't involve lasting meaning but keep the traces with persistent meanings, like the theme of flags and films."*



Figure: The remaining traces about specific theme after filtering

Preserving such traces helps in maintaining a cohesive and recognizable atmosphere, which fosters a sense of belonging and familiarity for participants. In placemaking, it is crucial to ensure that the environment remains coherent and well-organized. By selecting to keep traces that align with persistent themes, participants contribute to the continuity and coherence of the virtual place. This strategic approach prevents the environment from becoming fragmented or chaotic, making it more accessible and enjoyable for participants to engage with. Effective placemaking requires a delicate balance between preserving meaningful elements and encouraging innovation and change. Participants'

conscious decisions to cover certain traces while preserving others reflect a thoughtful and intentional effort to strike this balance. This approach ensures that the virtual environment remains vibrant and relevant while honoring its history and the contributions of its participants.

5.4.4 Differences with physical placemaking

Participants perceived differences between virtual and physical environments, especially in terms of publicness and anonymity.

In physical environments, people are alway aware of their surroundings and the presence of others, which creates a sense of being in a public space. This awareness makes people easily feel that their actions and interactions are observable by others around them. In contrast, in virtual environments, participants can feel the difference in the degree of publicness.

> *"In the virtual environment, I don't think my actions or traces will be received by the public. So I made a decision very randomly and without any further concern and consideration. But if I am leaving traces in a physical place, there will be greater psychological stress and need stronger motivation to do something."*

In physical environments, individuals are often recognizable by their physical appearance and features, which can lead to a sense of personal accountability for one's actions like stating something with traces. On the other hand, virtual environments offer individuals a higher degree of anonymity. Participants can act without revealing their true identities if they choose to keep the anonymity because traces are the only evidence and they will tend to lower their expectation on the impact their traces will have on this place. This anonymity can lead to different behavioral patterns and social interactions compared to face-to-face interactions. Participants might feel more liberated to express themselves or take on different personas in virtual environments due to this perceived level of anonymity.

6 CONCLUSION AND OUTLOOK

This chapter states the conclusion from my research and discusses the limitations and potential future work.

6.1 Conclusion

In the physical environments, traces of use will enhance the process of placemaking. When I try to introduce the concept of trace into virtual placemaking, the question is whether the trace can be exploited and its effect can be achieved in the virtual environment, which rely on both vision interaction and action interaction. My study indicates that traces' recognizability and persistence are also evident in virtual environments. Participants admitted that the traces enabled them to draw connections to others and places just like in the physical worlds. In my study, both quantitative data, qualitative interview and observation shows that traces play a profound and transformative role in the process of placemaking in virtual environments. As individuals actively engage in leaving traces of their actions, expressions, and interactions, they co-create and shape the virtual space. The dynamic nature of trace-centered behavior fosters continuous interactions, collaborations, and emotional connections among participants. Traces not only serve as a means of self-expression but also facilitate a sense of community and belonging as individuals respond and build upon each other's contributions. Through dynamic interaction and modification of traces, virtual environments become vibrant and evolving digital landscapes, reflecting the collective efforts and narratives of the participants. The findings of this study suggest that traces have a clear potential to significantly enhance social presence, cultural presence and exchanges, and contribute to the creation of meaningful virtual places where individuals can freely express themselves, connect with others, and contribute to a shared sense of identity and belonging.

6.2 Limitation

6.2.1 Participant sample

My study design is limited because there are only 3 participants and the participant sample is recruited via personal networks. These participants are all Carnegie Mellon University students which means that they have basic but context and understanding about the Fence. That enables them to get familiar with the virtual fence more quickly

and to give effective insights about the difference between placemaking in the physical environment and virtual environment. None of the participants had been familiar with the study before, but the knowledge about the physical fence will affect their feeling and behavior in the virtual fence. Some other findings about understanding places can be got from another study where participants know nothing about the CMU Fence.

6.2.2 Technical limitations

During the process of study, some participants argued that their willingness and behavior were affected by the interaction in the virtual environments. The interaction of traces is limited to painting on the fence with different colors but the same painter size. They asked some questions about potential interaction, like “Can I change the size of the painter ?” or “Can I erase the existing traces on the fence?”. Although my study does not aim to focus the method of interaction about traces, the interaction implementation will be an affecting factor in my study.

6.3 Contributions

This study on "traces to enhance placemaking in virtual environments" has shed light on the significance of traces and their impact on the process of virtual placemaking. It demonstrates how traces can influence the atmosphere, dynamics, and sense of place, contributing to the creation of quality virtual places. The study's findings provide valuable insights for designers and practitioners working on virtual environments. It promotes understanding and exploration on how to apply the concept and knowledge of physical space venue creation to the creation of virtual venues, which can guide the creation of virtual spaces that foster a stronger sense of place.

6.4 Future work

While this thesis provides some valuable insights, there are several avenues for future work to expand and gain more insights and understanding about this topic. To understand the generalizability of the findings, future work could explore different virtual environments and traces with varying features and functionalities. Comparative analysis would allow researchers to identify how the characteristics of specific platforms or interfaces influence trace-centered behavior and placemaking outcomes. Comparative studies comparing different types and features of traces and various trace-making tools and interaction can explore the different effects of traces' types and mechanisms on virtual placemaking.

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August 2023

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Appendix 1: Semi-structured post-study interview questions

Participants were asked questions concerning:

1. The process of placemaking
2. Differences between different rounds of study
3. The emotional experience change during the process

Can you describe your experience of the placemaking process in this virtual fence? How did you approach creating traces and interacting with others' traces throughout the study?

As the study progressed through different rounds, how did those traces and changes influence your sense of connection to other people or the place?

How has your emotional experience evolved during the 3-round placemaking? Have there been any significant moments or interactions that elicited strong emotions or changed your perspective in the process?

Can you reflect on your first experience into the virtual fence compared to your current perception after three rounds of study? Have your attitudes, motivations, or goals in it shifted over time?

In what ways have you felt connected to other participants during the study?

How have the interactions or the interpretation of traces influenced your own behavior pattern and decision making?

How did you decide what traces to create or modify in the virtual environment? Were there any specific inspirations or motivations that guided your actions?

Have you experienced any challenges or obstacles during the placemaking process? How did you navigate or overcome them?

Can you identify any specific traces or interactions that had a particularly meaningful or memorable impact on your overall experience during the study?

Looking back at the whole placemaking study, how would you describe the change of the sense of place in this virtual environment? How has your understanding of the place evolved over the course of the study?

Appendix 2: Saved texture with traces in the study

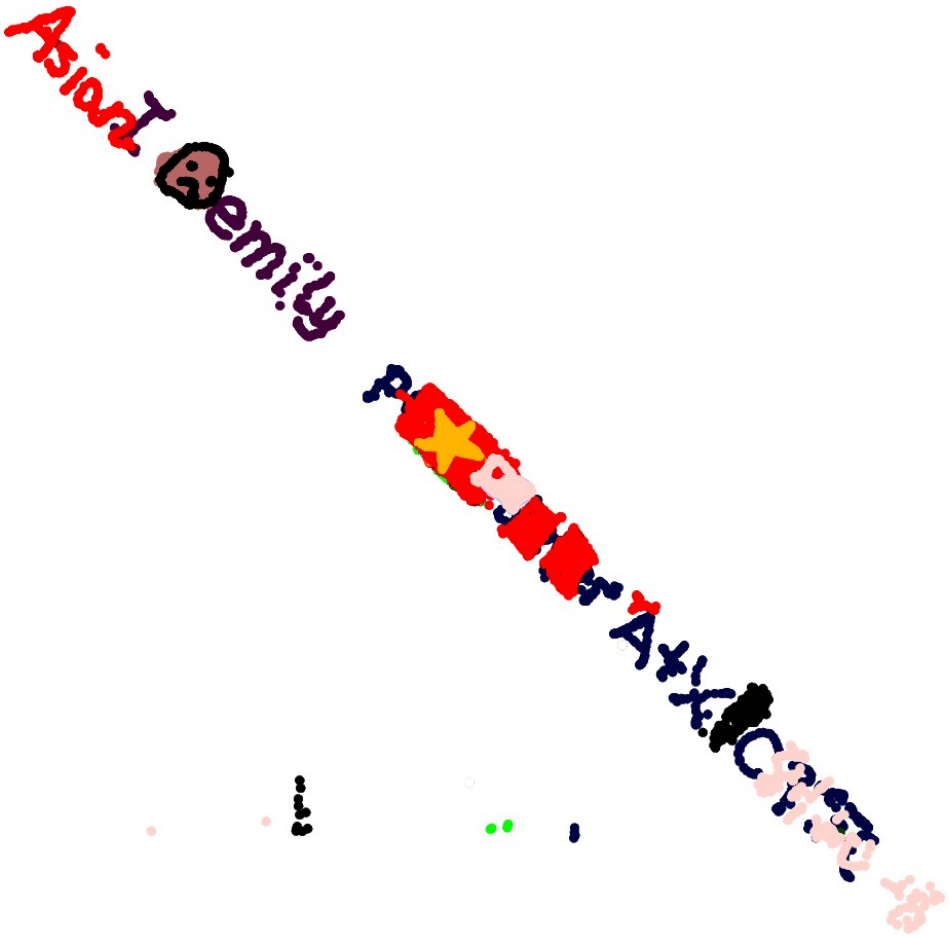
Overview of the process(left-to-right for PA-PC, top-to-bottom for Round1-Round3):



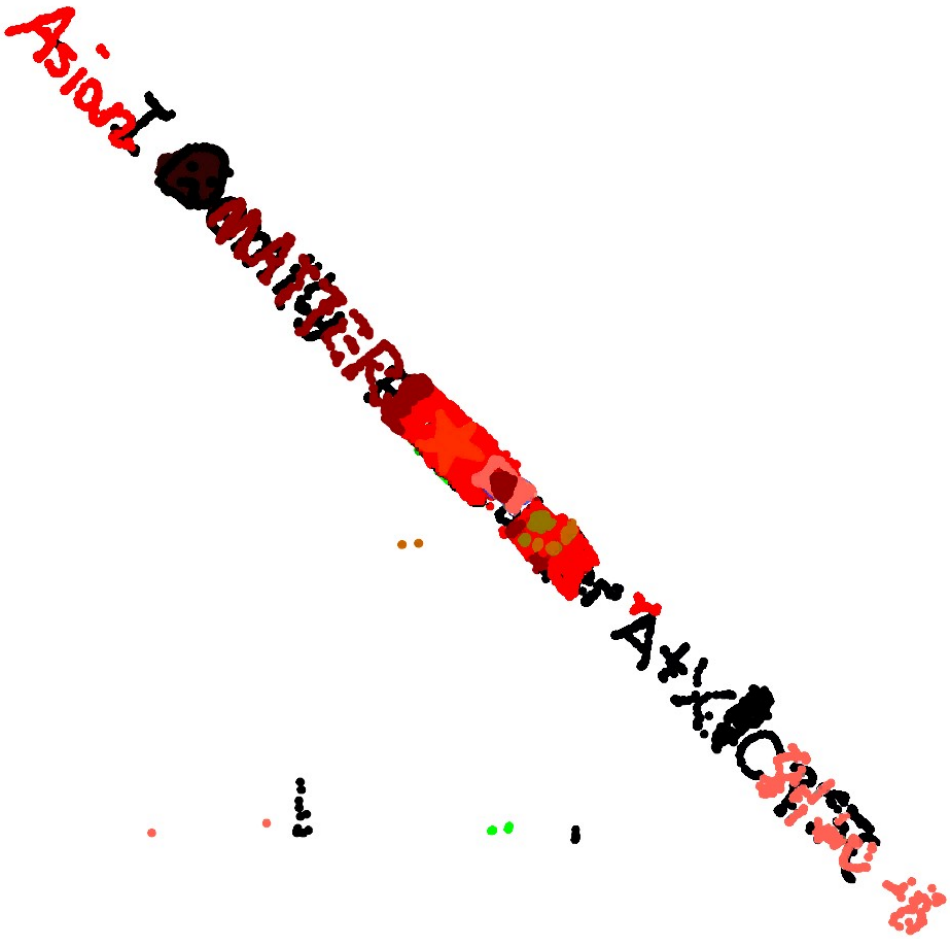
Texture R1PA:



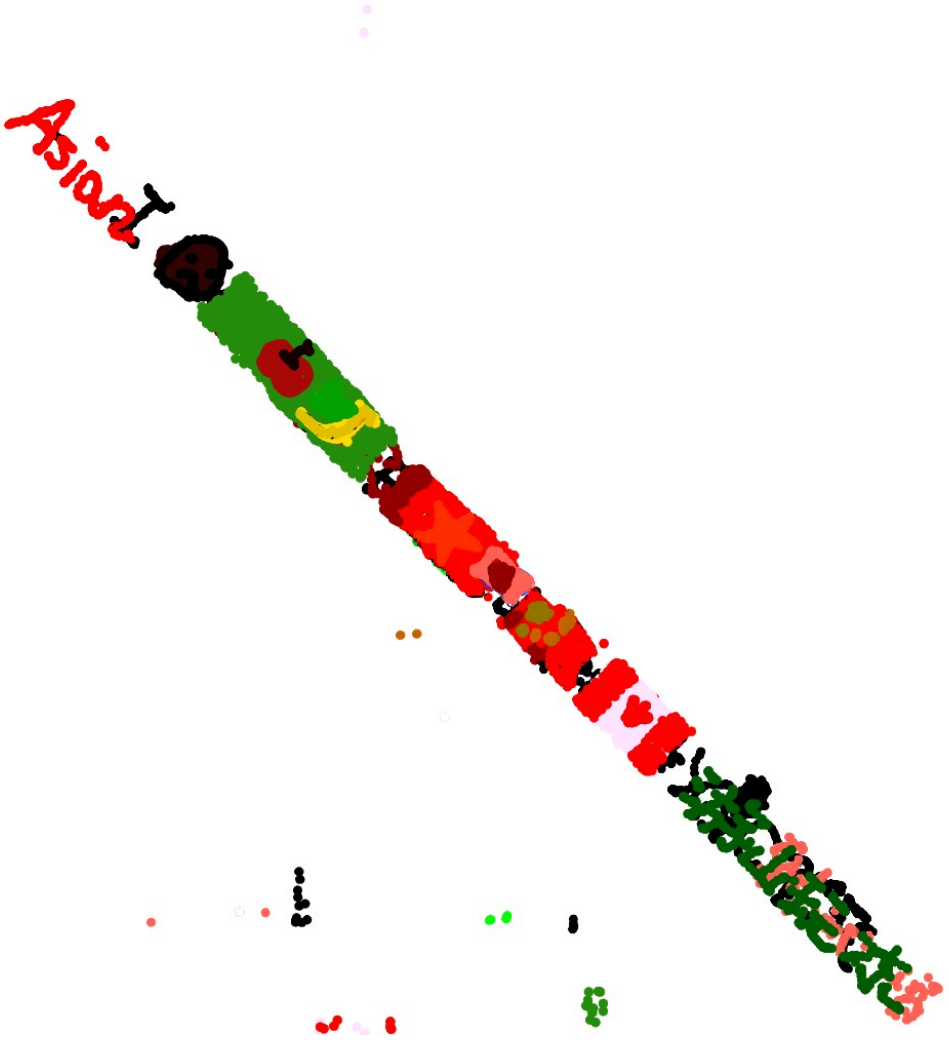
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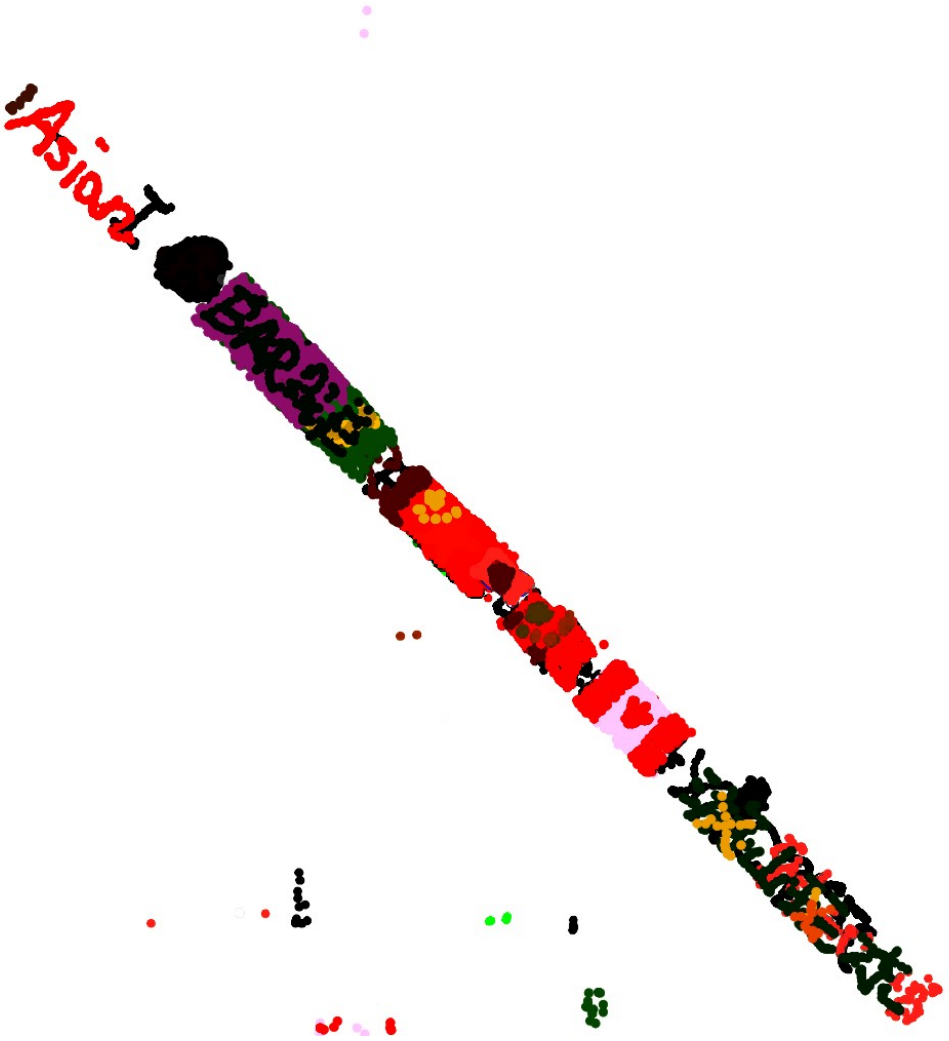
Texture R1PC:



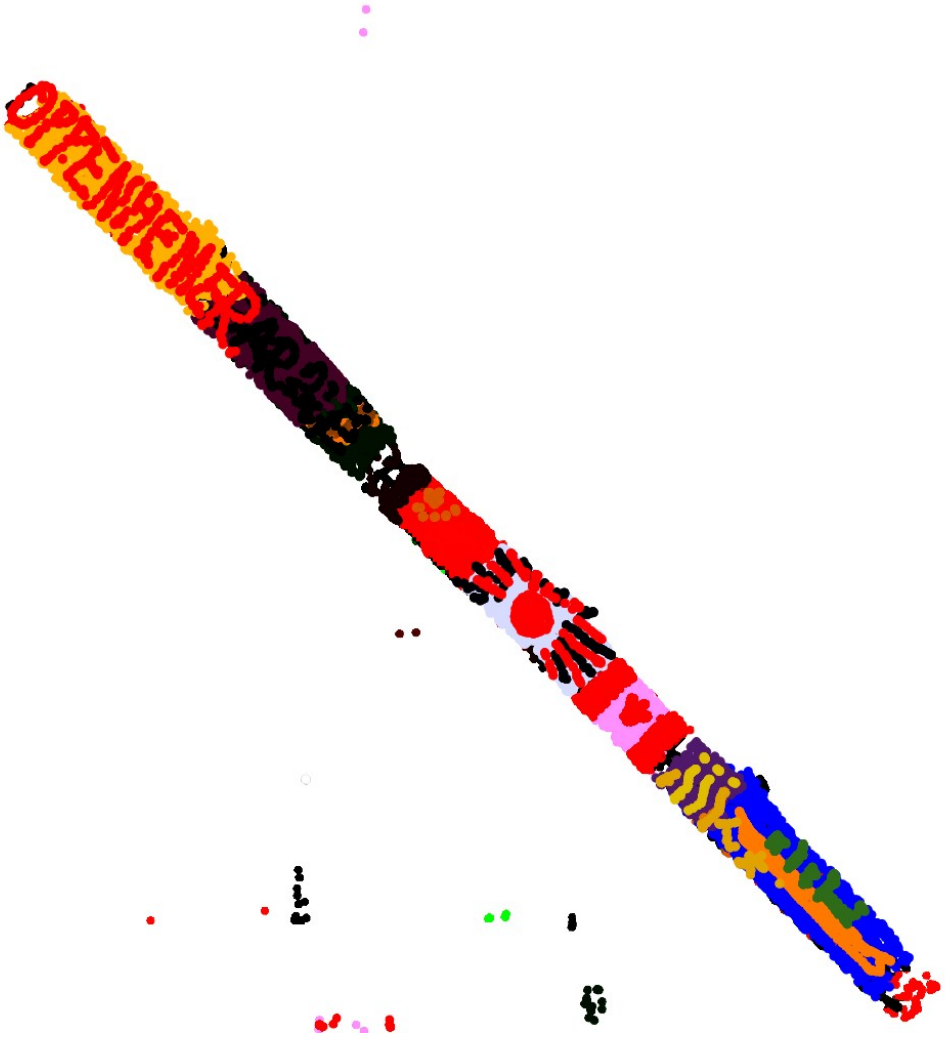
Texture R2PA:



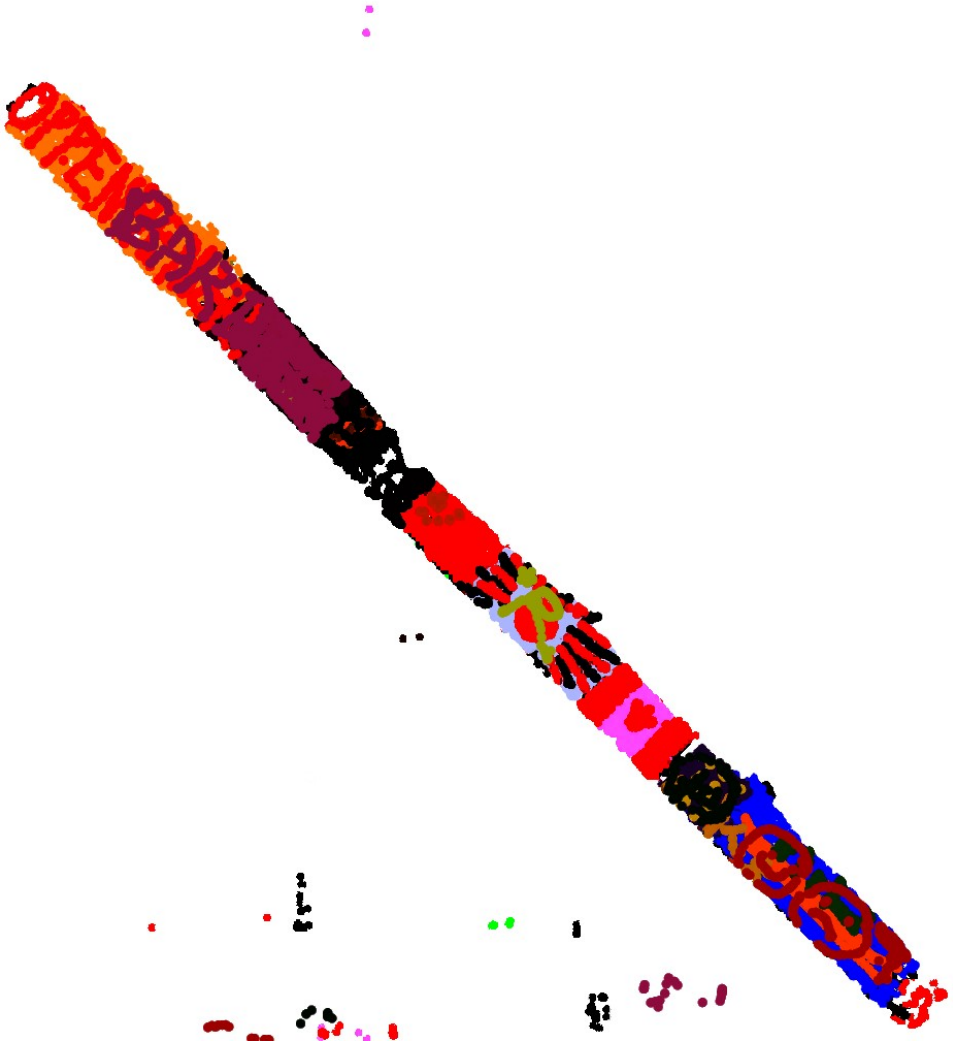
Texture R2PB:



Texture R3PA:



Texture R3PB:



Texture R3PC:

