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Virtual Craft: Experiences and Aesthetics of Immersive Making Culture

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Abstract: As immersive media, including VR, AR, MR, and XR, continues to expand rapidly during the pandemic era, there remains limited research on its comprehensive characteristics and its potential to create new forms of experience and aesthetics. This may be attributed to a lack of an understanding that immersive technologies exist encompassing both realms of reality and virtuality, leading to misconceptions that they are radically disconnected from traditional notions of materiality. In contrast, this study identifies an emerging trend characterized by the material implementation of immersive technologies in the domain of making culture in VR, which is referred to as "virtual craft" in this research. By reviewing studies on immersive media, materiality, making culture, and triadic semiotics, an integrated conceptual framework was developed to assess the experiences, aesthetics, and potential of immersive making culture. This framework is then applied to a specific case study involving virtual craft, with a particular focus on the 3D painting application, Tilt Brush, and related applications that the author has observed and tested. In conclusion, this paper presents a vision of the future of virtual craft and discusses the sustainability of immersive making culture, highlighting the potential for continued innovation and integration in various fields.

Keywords: immersive media; materiality; making culture; triadic semiotics; experience; aesthetics; virtual reality; craft; Tilt Brush

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1. Introduction

The COVID-19 pandemic has accelerated technological advancements and academic research on extended reality (XR) technologies, including augmented reality (AR), virtual reality (VR), and mixed reality (MR), in recent years (Chen et al. 2022). The pandemic, with its social distancing measures and restrictions on offline activities, has highlighted the need for online experiences that effectively replicate the offline world. As a result, in the current post-pandemic period, the XR market has grown increasingly and has also been segmented across various domains, such as solutions, applications, and end-user industries (Mordor-Intelligence 2023).

While often referred to as "immersive media" (Kaplan-Rakowski and Meseberg 2019), these technologies are not entirely new concepts and have been the subject of technological and epistemological exploration for a considerable time. For instance, VR technology, previously named the "ultimate display" (Sutherland 1965), has existed for over half a century, evolving from a laboratory-based idea to practical and affordable systems (Slater 2009, p. 3549). Although the recent popularity of XR technologies has garnered significant attention during the global pandemic crisis, there have been attempts to understand immersive media based on their unique conventions and possibilities (Bosworth and Sarah 2018; Klippel et al. 2019).

However, immersive media have often been viewed as a means of simulating existing realities rather than as distinct media capable of creating new forms of experience and aesthetics. This limited understanding of immersive media can be attributed, in part, to reliance on the reality–virtuality (RV) continuum (see Figure 1) for decades to explain the

range of virtual and augmented reality (Milgram and Kishino 1994; Milgram et al. 1994). While the RV continuum has provided a useful framework for introducing these technologies to both academia and the public, it restricts our comprehension of immersive media to a binary understanding between the two extremes of reality and virtuality, overlooking the nuanced and complex nature of immersive realities generated in AR or VR (Skarbez et al. 2021, p. 2; Bolter et al. 2021, loc. 445).

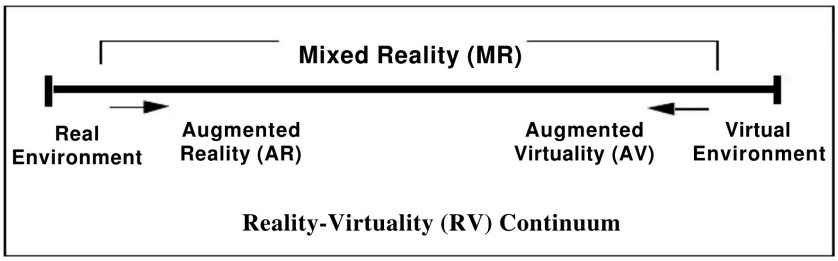


Figure 1. Simplified representation of the RV continuum (Milgram et al. 1994, p. 283).

This study aims to explore the nature of immersive media, with a particular emphasis on the materiality aspect. Despite the rapid expansion of immersive media during the pandemic era, encompassing diverse domains such as communication systems (Kachach et al. 2021), learning environments (Florez M. 2022; Stavroulia et al. 2021; Hollick et al. 2021), social networking (Langa et al. 2022; Kim et al. 2023), and healthcare (Bansal et al. 2022; Powell et al. 2022), there has been limited research into their material aspects. While immersive technologies may appear to challenge traditional notions of materiality, as particularly seen within the field of digital heritage (Al-Thani and Liginlal 2018; Trichopoulos et al. 2021), this study pays attention to a new form of material implementation that has emerged within the context of VR making culture, referred to herein as "virtual craft". The decision to focus exclusively on VR was motivated by its relatively extensive history of scientific development and unique ability to provide a fully immersive environment, distinct from AR's complementary experience and MR's hybrid approach (Greengard 2019, p. 18). VR's total immersion creates an environment particularly suited for investigating the nuances of virtual craft, effectively allowing for a complete disconnection from the physical world and remarkably enabling the creation of new, digitally constructed realities.

To establish a comprehensive understanding of this phenomenon, I developed an integrated conceptual framework through an extensive review of the literature spanning immersive media studies, materiality studies, making culture, and triadic semiotics. This framework was purposefully designed to examine both the experiences and aesthetics inherent to what I term "immersive making culture", defined as a culture of creative production within immersive environments. I then applied this multidimensional framework to a case study of virtual craft, focusing on Tilt Brush and its applications. In conclusion, this study offers insights into the future of virtual craft, discussing the sustainability of immersive making culture. It highlights the potential for ongoing innovation and interdisciplinary integration, shedding light on the emerging forms of creative expression driven by the dynamic realm of immersive media.

2. Literature Review

2.1. Immersive Media Studies

Immersive media has been a longstanding subject of interest in mainstream media studies. A consistent challenge within this domain has been how to address the inherent limitations of media, which falls short of replicating our inhabited three-dimensional world constantly filled with multisensory stimuli, despite significant advancements. The desire for a more holistic sensory experience has thus persisted, with the expectation that new media could extend our consciousness into novel realms and allow us to explore

unfamiliar places and experiences (Bolter and Grusin 1999; Manovich 2000; Bolter et al. 2021). From an archaeological perspective, the historical lineage of immersive media frequently leads us to the roots of image-based art. This exploration not only mirrors humanity's perpetual pursuit of representation (Grau 2003) but also paves the way for new territories, such as virtual archaeology (Benito et al. 2013; Lužnik and Klein 2015; Paradis et al. 2019). In this context, scholars argue that the term "immersion" should extend beyond technologies to encompass any deeply engrossing human activity or societal experience (Dogramaci and Liptay 2016; Wolf 2013), including both mass media from previous eras and today's digital culture (Freyermuth 2016). Recent academic discussions on immersion and its media counterpart have actively adopted a technological perspective, underscoring the revolutionary potential of digital ecosystems in reshaping industries and societies with new business models, digital consumers, and cross-media technologies, to better understand immersive experiences (Stiegler 2021). The upheaval brought on by the COVID-19 pandemic has accentuated this transition, altering our connections to the external world and consequently leading to a change in our perception of reality itself.

While largely concurring with previous research and the definitions provided by scholars in the field, my perspective on immersion emphasizes the experience as the core of the concept. Immersion thus emerges as a comprehensive experience, shaped by apparatuses that harness a multitude of sensory inputs and interactions to forge a convincing media environment. Central to achieving a level of immersion is an approach grounded in materiality, which makes the experience tangible and believable. Given the interdisciplinary nature of immersive media, I find it crucial to revisit and synthesize established concepts from various disciplines. A case in point is the concept of remediation introduced by Bolter and Grusin (1999) within the broader theoretical framework of intermediality (pp. 21–44). Remediation underscores the interdependent relationship between immediacy and hypermediacy. Immediacy aims to create a fully immersive experience, where the medium itself fades into the background, allowing viewers to believe they are present with the represented objects. On the other hand, hypermediacy acknowledges the presence of the medium and the technological interface, such as VR headsets or AR glasses, through which the medium is experienced. This concept of the "double logic of remediation" (Bolter and Grusin 1999, pp. 3–15) arising from the interplay between immediacy and hypermediacy provides a relevant lens to understand the functioning of contemporary immersive media. These media are designed to maximize immediacy, aiming for an interface without an interface, while intentionally incorporating elements of hypermediacy that provide random access to media technologies, thereby constantly reminding audiences of their desire for immediate experiences and opening up new possibilities for storytelling and communication in the immersive media's content.

The study of immersive media extends beyond traditional media studies and integrates perspectives from technical disciplines, such as computer science and cognitive science. Slater introduced the concept of immersive virtual environments, focusing on how individuals realistically respond within these virtual spaces (Slater et al. 1994; Slater and Wilbur 1997; Slater 2009). These responses encompass various levels, from physiological to emotional and behavioral aspects (Sanchez-Vives and Slater 2005). Slater critically examined the concept of "presence", which refers to the subjective sensation of being in a real place. To foster more precise scientific discussions and navigate the ambiguities surrounding the term presence, Slater proposed alternative terminologies anchored in the concept of "illusion" and the accompanying human behaviors, providing a nuanced perspective informed by computer science. These alternatives include "place illusion" (PI), which denotes a strong illusion of being in a place despite the awareness of not being physically present, and "plausibility illusion" (Psi), which refers to the illusion that what is happening is truly happening, even though one knows it is not (Slater 2009, pp. 3551–4). While PI focuses on how the world is perceived, Psi pertains to what is perceived.

Building on Slater's insights into both the technical environment and the cognitive interpretation of immersive technology, this study sought to reconstruct the concepts of PI and Psi. Additionally, it introduced the concept of "embodiment illusion" (Ebi), given that theories of embodiment have been the subject of extensive interdisciplinary research in recent decades (Lakoff and Johnson 1980; Gibbs 1994). These concepts are instrumental to understanding key aspects of immersive media and their content, including immersion, presence, and engagement (Bosworth and Sarah 2018, pp. 7–10; Bucher 2018, pp. 6–8). Furthermore, the relationship between these three illusions and the narrative principles of 5W1H (who, what, when, where, why, and how) was identified.

- Plausibility illusion (Psi): Within an optimal immersive media system, various sensory displays are typically coupled with a tracking system. Notably, the degree of immersion is largely determined by the system's physical attributes, which are frequently associated with hypermediated technologies. The question, "what is happening?" raised by participants, can be addressed through the operation of the plausibility illusion.
- Place illusion (PI): The concept of presence, which refers to the sensation of being in a particular location, has its roots in teleoperator systems. In immersive media, participants experience a sense of existing within the depicted place and time through the use of immersive displays. The manifestation of place illusion is contingent upon participants probing the limits of immediacy. The more they inquire about "where is it?" and "when is it?", the more the likelihood of interruptions in the illusion of being present increases.
- Embodiment illusion (Ebi): In immersive media, the human body serves as the nexus where the place illusion and plausibility illusion intersect. These media do more than just reshape our perception of place and reality; they also modify our bodily awareness. When a participant has a strong sense of presence (PI) and perceives the unfolding events as real (Psi), both their body and mind engage fully, reacting as though the experience is truly happening to them. Notably, the embodied cognition experienced during the actual perception of an object can be readily reactivated and relived, even when the object is absent (Lakoff 2012, p. 781). As such, the embodiment illusion underscores the integration of physical and cognitive processes, amplifying the overall immersive impact of the experience.

In summary, the world of immersive media operates by initiating immersion through the use of plausibility illusion, which addresses the question of "what is happening?" This establishes a foundation for the sense of presence, which is built upon the place illusion and addresses the questions of "where is it?" and "when is it?" As the sense of presence intensifies within the immersive media, the users become more engaged with the experience. This engagement is facilitated by the utilization of embodiment illusion, as users seek to understand "why am I here (there)?", "how do I exist here (there)?", and ultimately "who am I in this world?" These three components work together to create a rich and captivating immersive media experience, involving users on multiple levels of immersion, presence, and engagement (see Table 1).

Table 1. Key components of immersive media centered on illusion.

Psi	PI	Ebi
Immersion	Presence	Engagement
Hypermediacy	Immediacy	Remediation
What	Where When	Why How Who

2.2. The Study of Materiality, Making Culture, and Crafting

In recent years, the study of materiality has undergone significant advancements, leading to the re-evaluation of theories and concepts across various disciplines. Notably,

scholars in this field have attempted to both distinguish their work from historical materialism and critically revise it, an endeavor that has garnered considerable attention. The emergence of new materialism (Coole and Frost 2010) has particularly challenged historical materialism by advocating a more holistic understanding of materiality, one that extends beyond viewing it merely as a product of historical and social relations. In critiquing historical materialism, new materialists argue that it neglects the agency of both human and non-human actors and underestimates the inherent importance of materiality (Bryant 2014). Instead, new materialists offer a dynamic conceptualization of materiality, framing it as a series of actions (Grant 2006).

Drawing on the insights of thinkers like Whitehead ([1925] 1967; [1929] 1978; [1938] 1968), scholars have posited that our universe is made up of "real things" and emphasized the interconnectedness of humans and other entities within a shared "common world". In this perspective, subjectivity is understood as being immanent and all-encompassing, no longer a characteristic solely of humans, individuals, or intentional subjects (Latour 1999, p. 23). In this context, each entity is seen as an active presence participating in ongoing processes, as opposed to existing in isolation with a fixed identity (Shaviro 2014, loc. 101–2).

This new approach to materiality extends to the dimensions of objects, experiences, and aesthetics. Within this framework, the focus shifts to the actual existence and actions of things. Thus, things are not merely objects of knowledge but are entities that are meant to be experienced. Overall, the discourse on materiality has evolved to emphasize the active and interconnected nature of material entities, challenging traditional conceptions of materialism. It delves into the experiential aspects of things, their interrelationships, and their aesthetic qualities, reflecting the complexities of our contemporary material world shaped by digital technologies.

In light of the current ecosystem and the technological environment of the digital civilization, the culture of "making" has emerged as an active expression of the materiality of objects. As the global ecological crisis deepens and the Fourth Industrial Revolution, which is characterized by advanced technology and innovations in labor, continues to unfold, the discourse on making culture has emerged through manifestos and movements that advocate for active practice and participation. The concept of the "maker movement" represents a new paradigm that emphasizes the sharing of production tools within "community commons" and the accumulation of "digital commons" based on open-source principles, which can be applied to the material world (Anderson 2012; Hatch 2013). The maker movement seeks to foster the sharing of tools, not only to reduce production costs but also to establish infrastructures for collaborative production, such as Makerspaces and FabLabs. These collaborative communities enable practical outcomes through peer production and embody the concept of "intercreativity" advocated for by Berners-Lee (1996).

The study of materiality and making culture is deeply intertwined with the concept of craft. Craft emerges as a powerful human impulse, serving as an essential aspect of human existence, where our manual dexterity is what truly makes us fundamentally human (Charny 2011, p. 7; Shales 2017, loc. 41). Craft goes beyond fulfilling practical needs; it satisfies our desires and the intrinsic yearning to excel in a task. Sennett's concept of Homo faber, emphasizing humans as makers, highlights how the skillful practice of craft can lead to a more humane material life (Sennett 2008, loc. 81–85).

To grasp the multifaceted essence of craft, I have synthesized key concepts from the preceding literature reviews and introduce Table 2, detailing my conceptual framework of craft. Within this structure, craft is segmented into two primary dimensions: Experience and Aesthetics. Each of these dimensions further unfolds into specific subcomponents.

Table 2. Conceptual framework of craft.

Craft	Experience		Aesthetics	
	Object	Event	Relation	Power

- Experience: This facet of craft delves into the sensory, motoric, and emotional dimensions that collectively shape the holistic experience of crafting. It is segmented into two subcomponents—object and event.
    1. Object: Central to the crafting process, this subcomponent emphasizes the tangible materials and tools. Their involvement not only determines the final product but also amplifies the sensory connection of the maker.
    2. Event: Capturing the less tangible yet equally vital aspects of crafting, this subcomponent encompasses the maker's motoric reactions and emotional resonances, the ambiance of the crafting environment, and the inherent temporal evolution of the crafting experience.
- Aesthetics: Craft, recognized as a fundamental facet of human existence, embodies both the appreciation of beauty in the crafted item and the profound expression of human dexterity and societal values. This dimension can be distilled into two subcomponents—relation and power.
    1. Relation: Rooted in the interconnected nature of crafting, this subcomponent accentuates the ties between the maker, the crafted item, and the broader crafting community. It signifies more than just shared values and a collective sense of belonging—it represents our innate dexterity and the fundamental human drive to create.
    2. Power: This subcomponent celebrates the capacity of craft to communicate powerful messages and values beyond mere visual appeal. Through its transformative potential, craft can evoke profound emotions, incite reflection, and even advocate for a more humane material existence.

Craft enables us to propose viable ways of using tools, organizing bodily movements, and thinking about materials. It allows us to establish meaningful connections between our daily experiences and the objects we interact with, contributing to a deeper sense of relationality. Craft expands our abilities to communicate and connect with others across time and space (Margetts 2011, p. 43). In essence, craft offers a profound way of conducting life with skill and intention, enriching both individual and collective experiences, and striving for excellence and aesthetics.

In summary, the concept of craft fosters a deep understanding of the human material experience, encompassing objects and events, and provides a medium for engaging aesthetically with the world around us. Through the exploration and appreciation of craft, we unlock the potential for personal growth, social relations, and cultural empowerment (see Table 2).

2.3. Triadic Semiotics

The third literature review in this study explored alternative perspectives on the critique of semiotics in the study of materiality and craft and proposed a convergence model that examines the intersection of immersive making culture and semiotics. The study specifically focused on multidimensional integration based on the principles of "triadic semiotics" established by Peirce. His semiotics encompassed a general theory that deals with the concept and properties of signs, as well as the principle of signification. It is divided into various domains, such as phenomenology, normative science, and metaphysics (Lee 2017, p. xxiv). Peirce's sign concept, which consists of a triadic relationship between the representamen, object, and interpretant, addresses three key issues arising from observing and experiencing the world. It considers the object itself, the relationship between the object and the sign, and the way the object is represented. While Peirce's triadic system underwent shifts and expansions in its formal sign categories according to the characteristics of each period of his ideas, the irreducible triadic relationship of representation remained consistent (Lee 2017, pp. 20–22). In contrast with Saussure's dualistic semiotics, Peirce aimed to identify the generative nature of signs and discovered the signifying power present in "objects" that was not present in Saussure's conception of the sign.

Peirce's work on the classification of signs became increasingly complex as he refined his original propositions. However, it is important to recognize that the categories are not separate and can function together in sets. He defined three categories of signs in terms of object–representamen relationships, namely, icons, indexes, and symbols. An icon bears a physical resemblance to the object it represents. In contrast, an index has a direct connection to the physical reality or context in which it is situated. On the other hand, a symbol does not have an inherent logical connection to what it means. A symbol, such as the letters of the alphabet, requires us to learn and associate its meaning through cultural and linguistic conventions (Crow 2016, pp. 34–35).

Peirce's semiotics ultimately converged into a system of trichotomy that includes the categories of Firstness, Secondness, and Thirdness (Peirce 1931–1935; CP, 1.24–25, 1.377, 6.32). It is acknowledged that the nature of Peirce's categorization can be unclear as to whether it is ontological or phenomenological. However, Sheriff (1989) argued that this ambiguity is not due to a lack of consistency in Peirce's thought but rather reflects the different distributions of the material and formal aspects based on the properties of the subcategories (p. 67). Indeed, Peirce's triadic semiotics always remained grounded in the material basis of signs. According to Sheriff's interpretation (summarized in Table 3), Firstness refers to the concept of something "sui generis", that is, unrelated to anything else. It represents the "quality" of a phenomenon existing as a "possibility". Secondness, on the other hand, represents "facts" and "events". Secondness pertains to the dimension of "actuality", where beings relate to the universe, and facts occur as brute occurrences without specific reasons or rules. Finally, Thirdness involves the tendency of things to conform to general rules in predictable ways, termed "rationality". Time comes into play in Thirdness, which manifests as a "synthetic consciousness" accompanying life (Sheriff 1989, pp. 62–68).

Table 3. Classification of Peirce's triadic semiotics.

Firstness	Secondness	Thirdness
Possibility	Actuality	Rationality
Quality, sui generis	Facts, Events	General rules
Icon	Index	Symbol

Overall, this study delved into the incorporation of semiotics into the study of immersive making culture, with a focus on Peirce's trichotomies. It examined the triadic relationship between representation and the categories of Firstness, Secondness, and Thirdness, highlighting the material foundation of signs in Peirce's thinking. According to Peirce, the three categories of signs have distinct correspondences (see Table 3): the icon, which is based on the likeness of an object and represents the material quality of possibility in Firstness; the index, which is directly connected to the object as a matter of fact in Secondness; and the symbol, which establishes a mental relationship between the sign and the object in Thirdness (Sheriff 1989, pp. 67–68; Crow 2016, pp. 35–37).

2.4. The Integrated Conceptual Framework

Drawing upon Peirce's "three modes of being", I have synthesized prior discussions into a multidimensional diagram of immersive making culture, building upon my earlier research (Kim 2022). Figure 2 integrates the findings from Table 1, incorporating the three illusions, namely, plausibility illusion, place illusion, and embodiment illusion. In this integration, Psi represents the level of immersion based on the technological quality of a highly probable phenomenon, existing as a possibility in line with Firstness. Within the context of Psi, associated with the domain of Firstness, objects exist autonomously, separate from others. This distinctly differs from events, which, in Peirce's perspective, are anchored in actuality and the interconnectedness of entities. Thus, Psi is characterized not by the actual being but rather by the potential being, capturing the essence of similarity and resemblance, akin to an icon. On the other hand, PI initiates a sense of presence,

connecting individuals to actual events in depicted time and space, falling under the category of Secondness. In the realm of PI, and in alignment with Secondness, events transpire with certainty, materializing as undeniable facts in defined spatial and temporal settings. As Peirce posited, this domain corresponds to the index, marked by concrete causal connections with time and space, thereby offering a tangible sense of presence tied to specific locations and moments. Ebi, in conclusion, fosters a holistic engagement of both body and mind, underscoring the seamless fusion of physical and cognitive processes in accordance with the rational principles of Thirdness.

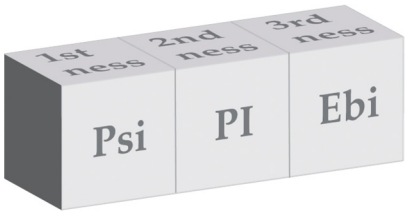


Figure 2. Diagram of the three illusions of immersive media and triadic semiotics.

The successful integration of Psi, PI, and Ebi—correlating with Firstness, Secondness, and Thirdness, respectively—is pivotal to fully grasping the immersive making culture. Psi focuses on the environment's plausibility, while PI emphasizes the user's spatial-temporal presence, collaboratively presenting a holistic perspective of immersion. Ebi is particularly salient within the immersive making culture, as it melds the user's physical interactions with cognitive engagement, both of which are indispensable during the crafting process. In essence, intertwining all three illusion aspects is vital for establishing a compelling immersive experience. Such integration empowers users to deeply connect with their circumstances, thus promoting active and enriched participation in the making culture.

Figure 3 provides a three-dimensional visualization of the conceptual framework of craft, as detailed in Table 2. As the table illustrates, craft is a blend of experience—comprising both tangible objects and intangible events—and aesthetics, which delves into relational dynamics and power. The framework underscores the intricate balance between the tangible elements of crafting—the objects and the tools—and the intangible elements—events or interactions between the craftsperson and their work. Concurrently, it accentuates the aesthetic elements shaping the crafted object, encompassing subjective interpretations and the impact of relations and power dynamics.

Figure 3. Diagram of the conceptual framework of craft.

Turning to Figures 2 and 3, they combine to produce Figure 4, which completes the diagram of immersive making culture. Psi, linked with Firstness, encapsulates positive qualitative possibilities and immediate feelings, operating independently of external references. This is joined by PI, aligned with Secondness, that signifies the existence of facts within a universe of existents, emerging from dynamic interactions between various objects. Collectively, these concepts forge an immersive experience characterized by distinct shifts in materiality. Such an experience integrates both the object and the event, elements fundamental to the essence of crafting.

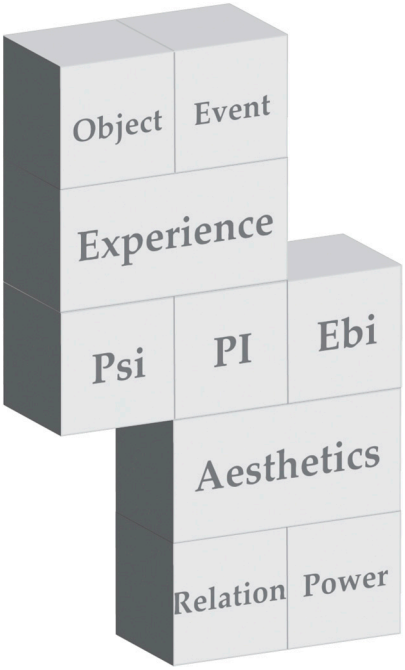


Figure 4. Diagram of the integrated conceptual framework of immersive making culture.

Furthermore, the interplay between PI—akin to Secondness, existing in relation to something else—and Ebi, which mirrors Thirdness in acting as a law governing facts, cultivates a unique aesthetic. This aesthetic emanates from the continuous interactions and encounters of objects, surpassing the confines of theory, practice, cognition, and ethics. In essence, the aesthetics shaped by PI and Ebi underscore the singular traits of an immersive making culture that actively recognizes and influences the relationships between various objects, and the empowerment stemming from them.

3. Analysis

3.1. The Landscape of Immersive Making Culture

To conduct empirical research on the immersive making culture in this study, reliable data were collected from the Meta Quest Store[1], which serves as the official marketplace for users of the Meta Quest headset. Developed and manufactured by Oculus, which is a subsidiary of Meta Platforms Inc. (formerly known as Facebook), the Meta Quest headset was launched in May 2019 as a standalone VR device. It quickly gained attention in the market due to its ease of use, portability, and high-quality VR experience. With its built-in display, sensors, and tracking capabilities, it offers an all-in-one immersive virtual reality experience without the need for additional hardware.

The subsequent launch of Quest 2 in 2021, an enhanced yet more affordable version, solidified its standing among both casual users and VR enthusiasts. As depicted in Figure 5, which provides a visual representation of the Quest 2′s user-friendly design and usage, the public-oriented evolution of hardware and its adaptation by users have contributed to the significant proliferation of immersive media, particularly during the unexpected pandemic era (Kuchera 2020). This serves as a concrete example of the immersive making culture explored in this research.

Figure 5. Images of Quest 2 released by Facebook.

Since the initial release of the Meta Quest, the Meta Quest Store has witnessed a significant increase in the publication of VR content, which is categorized into games, apps, and entertainment. While games have been the most successful category in terms of quantity and popularity, the other categories have opened up new possibilities for the immersive media ecosystem. The entertainment section includes traditional forms of media content, as well as interactive VR films, documentaries, experimental animations, and immersive expeditions. The apps category encompasses a wide range of activities, such as sports, social networking, learning, fitness, wellness, and creative endeavors. For this study, the "creativity and design" genre within the Meta Quest apps was selected to collect relevant data for the analysis of immersive making culture, which involves material thinking and manual dexterity in crafting.

Table 4 presents a list of thirty apps published in the creativity and design genre within the Meta Quest Store in the USA since 2019. Each app is accompanied by an introduction page that provides a brief overview, key features, and reviews and ratings from verified owners. Meta verifies the ownership of individuals who have purchased an app through the official store and logged into it for at least one minute (Meta Quest 2023). Reviews from verified owners that meet the company's standards are published. The introduction page also displays the percentage of star ratings received from these verified owners. Based on this information, this study classified the type of making represented by each app and calculated the average rating on a five-point scale.

By examining the types of making classified in Table 4, it was found that out of the thirty examples, the art category was the largest, comprising nine applications that involved crafts, such as painting, coloring, and 3D modeling. Following that, there were six applications with design themes, including spatial creation and world-building. Additionally, there were six media-related applications, offering features such as VR animation, VR stitching, and 3D video production. The music-related category consisted of four apps for composition and DJing. The remaining applications covered various areas, such as pottery making and 3D-based learning or ideation.

Table 4. List of creativity and design apps in the Meta Quest Store (accessed on 12 June 2023).

	App Title	Release Year	Total Number of Ratings	Average Rating out of 5	Type of Making
1	Vermillion	2022	677	4.82	Painting
2	PatchWorld–Multiplayer Music Maker	2022	164	4.77	Music creation
3	Kingspray Graffiti	2019	2463	4.63	Street art
4	StellarX	2023	27	4.56	Space creation
5	Tilt Brush	2019	1013	4.5	3D painting
6	Tribe XR | DJ in Mixed Reality	2019	845	4.49	DJing
7	Mistika VR Connect	2022	9	4.45	VR stitching
8	First Touch for Meta Quest Touch Pro controllers	2023	46	4.4	Painting
9	Painting VR	2022	425	4.38	Painting
10	Color Space	2020	511	4.37	Coloring
11	SculptrVR	2019	395	4.36	Space building
12	ShapesXR	2021	217	4.29	3D modeling
13	Virtuoso	2022	255	4.27	Music creation
14	MultiBrush	2022	132	4.24	3D painting
15	VR Animation Player	2019	426	4.24	VR animation
16	Figmin XR	2022	44	4.23	MR creation
17	Zoe	2022	48	4.12	3D scene creation
18	Gravity Sketch	2019	1016	4.09	3D modeling
19	Flipside Studio	2023	61	4.03	VR animation
20	Arkio	2022	147	3.94	Space design
21	Electronauts	2019	161	3.8	Music creation
22	Let's Create! Pottery VR	2020	195	3.74	Pottery making
23	Spatial	2020	513	3.69	World-building
24	Wooorld	2022	173	3.56	Trip-making
25	Home Design 3D VR	2023	96	3.41	Space design
26	YUR World	2023	33	3.41	Bodybuilding
27	Noda	2021	162	3.38	3D ideation
28	Villa: Metaverse Terraforming Platform	2021	1076	3.37	World-building
29	RiBLA Studio	2021	27	3.28	3D video
30	Prisms Math	2023	56	3.12	3D learning

Among the applications with more than 500 ratings, the highest-rated apps (see Figure 6) included Vermillion (painting), Kingspray Graffiti (street art), Tilt Brush (3D painting), and Tribe XR | DJ in Mixed Reality (DJing). These apps predominantly feature painting-themed content and have received positive reviews from users.

(**a**) (**b**)

(**c**) (**d**)

Figure 6. Screenshots of the highest-rated apps: (**a**) Vermillion[2]; (**b**) Kingspray Graffiti[3]; (**c**) Tilt Brush[4]; (**d**) Tribe XR | As a DJ in Mixed Reality[5].

3.2. Experiences and Aesthetics of Virtual Craft: The Case of Tilt Brush

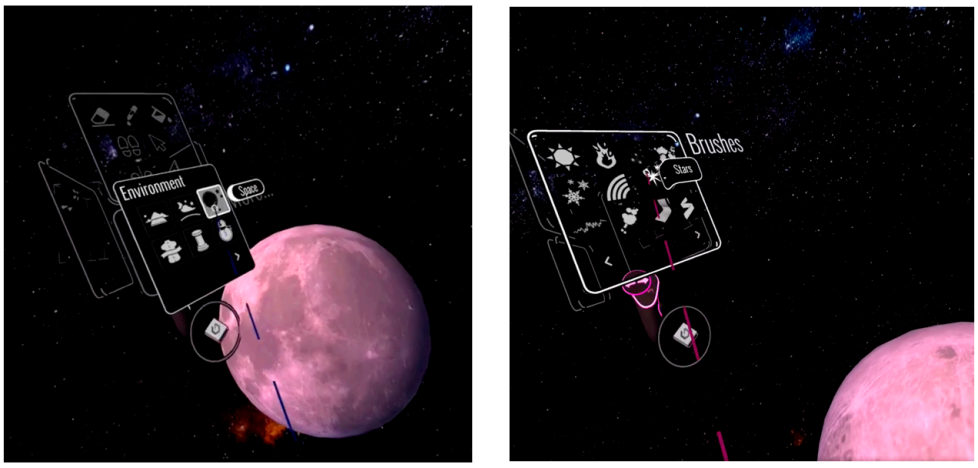
In this section, I present the results of a comprehensive analysis of the experiences and aesthetics associated with Tilt Brush, which serves as an exemplary case study to explore virtual craft—a subgenre within the immersive making culture that revolves around virtual reality. The decision to exclusively concentrate on Tilt Brush for this analysis was informed by several factors, including its early introduction to the market in 2019, the substantial number of user ratings (1013), and its high average ranking (4.5 out of 5). Furthermore, Tilt Brush's transition to open-source software in 2021 has made it even more influential, contributing to the development of other similar applications in the field of virtual craft.

The analysis of Tilt Brush was conducted based on the three key categories illustrated in Figure 4: plausibility illusion (Psi), place illusion (PI), and embodiment illusion (Ebi). Notably, this analysis was undertaken by the author of this study, who acted as the primary user, testing the Tilt Brush application and applying the theoretical framework to their own experiences. Data collection involved documenting personal experiences, recording observations, and critically analyzing interactions with the Tilt Brush application using the theoretical framework outlined earlier in the study. This first-hand approach allowed for a nuanced and personal understanding of the immersive making culture and the aesthetics of virtual craft.

3.2.1. The Psi of Tilt Brush

- Tilt Brush is a specialized three-dimensional painting program explicitly designed for head-mounted displays (HMDs), which serves as foundational instruments for delivering a robust virtual experience. Upon activating the application within the HMD, users are greeted with an extensive blank landscape complemented by an ambient soundscape. This object-focused setup provides an array of customization options for the virtual environment, including adjustments to lighting, background selection, and

the prevailing atmospheric hue (refer to Figure 7). Moreover, the application boasts preset scenic alternatives, such as a starlit night or a snowy winter day. These preliminary configurations not only lay the groundwork for upcoming crafting endeavors but also ground users in the realm of "what is happening", guiding them towards active engagement with the available tools and features. This preparatory phase is crucial for establishing the context before users venture into dynamic interactions, ensuring their sustained immersion in the designated virtual setting.



(**a**) (**b**)

Figure 7. Screenshots of the Tilt Brush features: (**a**) Environment feature (image by the author); (**b**) Brushes feature (image by the author).

- Once users have configured their desired environment, which offers a vast open space in 360 degrees, they naturally begin to explore the tools for painting. Each hand holds a motion controller; one acts as the palette for painting work while the other represents the painting tools, such as brushes or their virtual substitutes. The painting palette is meticulously iconized to resemble real objects, including various brushstrokes, paint colors, and 3D shapes (see Figure 7). While these virtual devices may initially feel hypermediated, the interaction with painting icons that closely resemble real objects gradually immerses the user.

3.2.2. The PI of Tilt Brush

- As emphasized by its tagline, "Your room is your canvas" (see note 4 above), Tilt Brush enables users to freely explore and utilize the three-dimensional space in front of them without the constraints of a physical medium. By using hand controllers as brushes and palettes, users can create the experience of life-size paintings vividly and up close. What may have once felt hypermediated is now perceived as a graphically friendly and intimate interface.
- The visual elements generated by Tilt Brush's painting feature, such as points, lines, and planes, exist as 3D objects with their vector values. Users can intuitively manipulate these elements in terms of their shape, size, and position, just as they would interact with physical three-dimensional objects (see Figure 8). These indexical interactions, occurring causally between the users' inputs and materialized outputs, further enhance the users' sense of presence, making them feel here and now in their own created canvas.

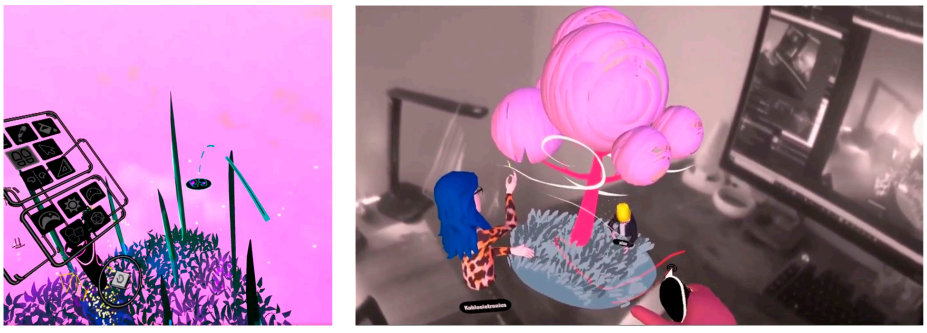
(**a**) (**b**)

Figure 8. Screenshots of the Tilt Brush operation: (**a**) 3D object scene (image by the author); (**b**) 3D painting scene (Google AR & VR 2017).

- During the development of Tilt Brush, Google initiated The Tilt Brush Artist in Residence (AiR) program, which invited over 60 artists from various disciplines to participate[6]. The program welcomed painters, graphic designers, graffiti artists, cartoonists, dancers, and IT technicians, among others. One notable commentator on the project was McCloud (Google AR & VR 2017), who observed the shift from traditional two-dimensional painting practices to the new reality of painting in three-dimensional space. In the virtual three-dimensional environment created by Tilt Brush, the artists found themselves encircling their works, and in turn, being encircled by their own creations (see Figure 8). Many artists who took part in the AiR program expressed similar experiences, describing the sensation of walking directly into their workspace or "inhabiting" their artwork.

3.2.3. The Ebi of Tilt Brush

- Tilt Brush's immersive making events blur the traditional boundaries between painting and sculpture, empowering users to engage with the world of "painted sculpture" and "sculpted painting" (Kim 2022, p. 28). By surpassing the limitations of 2D painting, it establishes new rationalities for three-dimensional expression and exploration, providing a unique way to interact with the virtual environment. One notable example is the teleport feature (see Figure 9) in Tilt Brush, which allows users to virtually hop to different spots within their environment, enabling them to determine their perspective and relation to the world as independent makers. This transformation in the maker–object relationship is also evident in the interaction between the artwork created in Tilt Brush and the user. The user actively engages with the 360-degree virtual space and is required to choose their narrative perspective at every moment. As a result, the power to shape the narrative of immersive content is largely transferred and decentralized to the users, who can now seek meaningful answers to fundamental questions, such as "why and how do I exist here?" and ultimately "who am I?" in this world.



(**a**) (**b**)

Figure 9. Screenshots of the apps features: (**a**) Tilt Brush's teleport feature (image by the author); (**b**) MultiBrush's multiplayer feature (Rendever 2022).

- In addition to the diverse power structures inherent in their immersive making processes and outcomes, Tilt Brush makers are extensively involved in nested relationships with other makers and the networked transformation of the digital ecosystem. The example of Tilt Brush illustrates how many immersive makers import 3D objects from online open libraries into their programs to modify them (or vice versa), extract their work as graphic files to connect with other applications, and contribute to sharing platforms. This trend has accelerated since Google released Tilt Brush as open-source code in 2021. The open-source code for Tilt Brush is readily available on its GitHub page[7], which is a key platform in the global development ecosystem that hosts source code and facilitates digital collaboration. Following the open-source release of Tilt Brush, a developer named Icosa[8] created Open Brush[9] on GitHub, which is essentially a free version of the original program. Icosa launched a beta version of a gallery to allow sharing of do-it-yourself creations and recently announced an XR version that integrates with real-world spaces. Another developer, Rendever (2022), utilized the Tilt Brush source code to create MultiBrush—a multiplayer version that lets multiple users connect simultaneously to collaborate on artwork (refer to Figure 9).

3.2.4. Summary of Tilt Brush Analysis

In this section, I present a concise summary of the findings from the analysis of the experiences and aesthetics of virtual craft, as explored through the case study of Tilt Brush, synthesizing the key points from the preceding sections on the Psi, PI, and Ebi of the application. As shown in Table 5, I have summarized the key findings of the analysis based on the previously presented integrated conceptual framework of immersive making culture.

Table 5. Key Findings from Tilt Brush Analysis.

Object	**Event**	
HMD with sound background menu iconic tools	device control 360-degree exploration 3D objects manipulation	
Experience		
Psi	**PI**	**Ebi**
	Aesthetics	
	indexical interface life-size painting artwork inhabitation	general rules of 3D painting decentralizing narrative open-source network
	Relation	**Power**

In terms of experience, Tilt Brush presents a unique crafting environment that seamlessly blends object-oriented and event-based elements. The object-oriented components encompass hardware features like the HMD and sound system, effectively immersing users in a plausible virtual setting. The background menu and iconic tools furnish a broad spectrum of objects for potential interaction, empowering users to manipulate the virtual space. On the other hand, the application's event-based attributes are highlighted by intuitive device controls, the freedom to traverse the virtual environment in a 360-degree panorama, and the power to sculpt 3D objects. This synergy of object and event features delivers a profound experience, positioning Tilt Brush uniquely compared to conventional art mediums.

Aesthetically, Tilt Brush is infused with relational and power dynamics. Features like the indexical interface, life-size painting, and the ability for creators to literally inhabit their own artwork highlight the interconnectedness between the creator, the crafted object, and the virtual environment. With respect to power dynamics, the program abides by the foundational principles of 3D painting, laying down the rules of engagement for virtual artistry. The decentralized narrative feature, offering a broader interpretation canvas for

art, coupled with an open-source ecosystem promoting collective creativity, truly sets the stage for an unparalleled virtual crafting journey. This not only accentuates the art creation process but also underscores the influence of these masterpieces within the wider virtual art community.

4. Discussion

The case study of Tilt Brush stands as a pivotal analysis, spotlighting the distinct characteristics of virtual craft experiences and aesthetics. By merging and refining these components, I aim to deepen the discourse on the immersive making culture and establish a universal benchmark for evaluating both experiential and aesthetic facets of virtual craft. Drawing upon insights from previous sections, I revisit the findings, amalgamating individual categories to delve into their implications within the broader domain of virtual crafting. This integrative approach culminates in the formulation of an assessment checklist questionnaire (refer to Table 6). In navigating this analytical landscape, my goal is to unearth and reflect on consistent themes and observations, emphasizing their relevance across a spectrum of virtual craft cases.

Table 6. Assessment checklist questionnaire for virtual craft experience and aesthetics.

Categories	Subcategories	Content
Experience	Object	• Does the virtual craft application utilize hardware components (e.g., HMD, sound system) to enhance immersion? If so, how effective are they? • How realistic or abstract are the virtual tools and materials in the application? When using them, can you easily discern "what is happening?" based on sensory feedback? • Does the application offer a wide range of creative possibilities, or are there clear limitations in its toolset?
	Event	• How intuitive are the application's device controls, and do they enhance your interaction with your crafted work? • Does the application allow you to explore the entire virtual environment freely, and how does this affect your crafting experience? • When sculpting or shaping 3D objects in the application, do you feel a deeper connection with your work, and does it influence your sense of time and presence?
Aesthetics	Relation	• How does the application foster interconnectedness between you, your virtual crafted object, and the entire environment? Are there features that particularly enhance this bond? • Does the application foster a sense of belonging to a broader virtual crafting community, or does your creative experience feel more isolated? • Within the application's context, can you identify shared artistic principles or techniques that seem to unify users, reflecting a collective drive to create?
	Power	• When interacting with virtual creations in the application, do you feel they effectively convey strong messages or values? • Do you feel more empowered in your creative process compared to other mediums? Do you feel you are at the forefront, shaping the narrative and content direction with your own unique perspective, enhancing a new sense of "who I am"? • How do the virtual creations contrast with traditional aesthetic norms? Do they offer fresh perspectives or challenge conventional views on contemporary issues?

5. Conclusions

This study aimed to explore the nature of immersive media, specifically focusing on their materiality and the role of physical agencies in our real world. By examining immersive media studies, materiality studies, making culture, and triadic semiotics, a comprehensive conceptual framework was developed to evaluate the experiences and aesthetics of immersive making culture. Through the integration of elements from each domain, a multidimensional model of immersive making culture was constructed.

To establish the concept of virtual craft, thirty VR applications within the Meta Quest Store were classified into specific making categories, and their acceptance and popularity were assessed. Among these applications, Tilt Brush emerged as a representative medium for virtual craft due to its widespread popularity and practicality. Through a detailed analysis of Tilt Brush within the context of the immersive making culture model, the experiences and aesthetics of Tilt Brush were examined, providing evidence of the feasibility and sustainability of immersive making culture.

The findings of this study were as follows:

- Virtual craft as an emerging trend in immersive making culture: This study identified a trend in immersive making culture that can be described as virtual craft. The scope of virtual craft appears to be gradually expanding beyond traditional art genres and forms of making, such as painting and composing music, toward more innovative directions, including spatial design, social networking, and world-building. This trend reflects the exploration of the new materiality in the media and opens up possibilities for future development.
- The current state of virtual craft: Through the construction and application of the immersive making culture model, significant characteristics of the current virtual craft were observed. One key aspect was its reliance on the iconic features of objects, emphasizing the plausibility illusion through hypermediated technologies, such as enhanced versions of HMDs. The narrative question of "what is happening?" took precedence over specific events or dynamic relations between various objects rooted in a specific time and space.
- Possibilities and limitations of virtual craft: The analysis of Tilt Brush, which was based on the integrated framework, revealed that this typical case of virtual craft enabled users to blur the boundaries between painting and sculpture, offering new rationalities for three-dimensional visual expression. The ability to freely navigate and manipulate virtual space using motion controllers enhanced the sense of presence and engagement, resulting in a transformative power relationship between the maker and the media. However, the case of Tilt Brush also highlighted the technical limitations of virtual craft in fully achieving its aesthetic goals, as there is an ongoing process of remediation between immersive media and traditional art forms.

These findings provide valuable insights into the future of immersive media and its sustainability. First, this study anticipated the need for further investigations into the broad range of making cultures and craft innovation from the perspective of digital materials. While the case of virtual craft was analyzed as significantly expanding the boundaries of materiality toward a new common world of digital objects and their empowerment, it is expected that future cases of virtual craft will incorporate more sophisticated indexical and symbolic elements, moving beyond the current reliance on iconic features. This direction is also associated with the evolution of the place illusion and the embodiment illusion within virtual craft applications, which will continue to establish authentic experiences and aesthetics in immersive media.

While acknowledging the inherent limitations of the top-down approach from theory to analysis, this study aims to contribute to the growing body of literature on the theoretical convergence of immersive media by emphasizing their materiality. It is hoped that this study will inspire further not only explorations and development of theories and concepts that deepen our understanding of the technical dynamics and cultural impacts of immersive media, but also wider empirical studies driven by data analysis. Through these advancements, we can continue to shape and redefine our existence within the digital civilization, with virtual craft serving as an important aspect of this evolving landscape.

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Notes

1 Meta Quest Store. Available online: https://www.oculus.com/experiences/quest/ (accessed on 7 July 2023).
2 Vermillion. Available online: https://vermillion-vr.com/ (accessed on 7 July 2023).
3 Kingspray Graffiti. Available online: http://infectiousape.com/ (accessed on 7 July 2023).
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