BIOPHILIC DESIGN: VIRTUAL NATURE APPLICATION IN A WINDOWLESS ROOM

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ABSTRACT

Biophilic design recommends the connection between humans and nature because it positively influences human health and well-being. Due to the pandemic, some humans have been forced to work at home or in windowless rooms. This situation makes occupants unable to connect with nature. One solution in biophilic design is to present natural substitute elements such as virtual nature to reconnect nature in spaces that cannot access it. This paper discusses the application of virtual nature in windowless space which aims to help users get positive benefits for affective well-being (AWB) such as emotions and moods. This paper is compiled through literature exploration by synthesizing various previous research results. Based on several studies, shows that virtual nature is not just replacing real nature but is a boundary of the interior that reconnects with nature. This connection emotionally determines the quality of the windowless room so that it has benefits for the well-being of the occupants, especially affective well-being (emotions and moods).

**KEYWORDS:** affective well-being, biophilic design, boundary, pandemic, virtual nature, windowless

INTRODUCTION

One of the ways for humans to improve their well-being is to relate to nature. This is also discussed in biophilia which explains the tendency of humans to be affiliated with nature (Wilson, 1984). In the case of windowless space, it causes a reduction or even loss of human access to nature. This is further exacerbated by the pandemic that has caused the WFH incident and prohibited leaving the house. Moreover, it has been stated in several studies that the impact of working at home influences their psychology. Some of the effects on psychology include depression (Tee et al, 2020), anxiety (Xiong et al, 2020), emotional distress (Cao et al, 2020), boredom (Ahmadi & Ramezani, 2020), and frustration (Tee et al, 2020). So, emotional support is still needed for several situations related to well-being, one of which is exposure to nature.

One of the contexts that underlie this research is the experience of the author who was in a boarding room that had no windows during the WFH period (see Figure 1). Similar conditions were also experienced by the occupants of the other room occupants. The case of rooms without windows is also explained in the data for rooms without windows by the 2019 Housing Statistics released by the Badan Pusat Statistik (BPS),

namely the requirement for rooms to have windows is ignored by some regions, especially in DKI Jakarta.

Only 37 percent of living rooms in the Capital City have windows (Anindita Maharrani, 2020).

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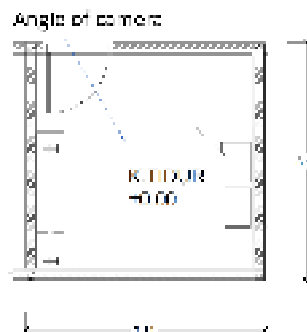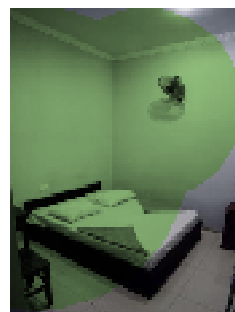
Figure 1. Kamar Penulis tanpa jendela
(Source: Personal Documentation)

The relationship of nature that can improve well-being, especially affective well-being in interior space

is also related to nature as a determinant of the quality of the interior (McCharthy, 2005). Affective well-being is a person's current state of well-being and is potentially more temporary, namely a person's short-term emotional and mood conditions (Eger & Maridal, 2015). This condition can be influenced by the environment (Eger & Maridal, 2015), including the quality of the interior caused by nature. However, in the case of a windowless interior it will cause problems, especially in the workplace because the existence of windows as a connection to nature is vital for the comfort and well-being of the occupants (Croome, 2001).

Connecting nature for those who cannot access it has been given a solution by biophilic design (Downton et al, 2016). Namely the virtual connection with natural patterns, such as virtual nature (VN) technology (Browning et al, 2020). Several studies have also discussed and researched this technology and its associated mental health and psychology (Browning et al, 2020). It was revealed that exposure to nature could virtually provide emotional well-being benefits for those who cannot access outdoor spaces such as windowless spaces and undergrounds (Browning et al, 2020). However, this technology has several contradictions, whether virtual nature provides access to re-connect with nature in the interior or cuts off this access because of the connection with nature that is not real. Virtual nature is also related to the sustainability of "human nature relationships", namely reconnecting humans with nature that is not actual.

Based on this, it is necessary to explore whether this technology is a solution that can indeed connect nature to the windowless interior. Especially to see whether the technology can improve effective well-being of the user or not. This research is study of literature that explores the relationship between virtual nature technology and the affective well-being of a person in a windowless room.

RESEARCH METHOD

This study uses a qualitative method (meta-synthesis) through a literature study on virtual nature applications in a windowless room.

We reviewed the scientific literature on virtual nature by searching the Elsevier database and book section, which provides scholarly articles related to the psychological architecture: windowless room, affective well-being, and virtual nature in biophilic design.

The publication date for the journal article, article in periodical, conference proceeding was set from 2019-2022 (isu covid mulai muncul) dan 1984 to 2022 for book reference. We used combination of terms to search the literature related to (1) biophilic design, (2) windowless room or windowless room, (3) affective wellbeing, (4) pandemic psychological issue, and (5) virtual nature. The keywords related to (1) biophilic design were "pattern", "visual connection","non visual connection"; the keywords related to (2) windowless room were "window" "interiority", "boundary"; the keyword related to (3) affective wellbeing were "emotions", "wellbeing with nature"; (4) pandemic psychological issue were "mental health","emotional distress", "anxiety", "quarantine", "boredom"; and (5) virtual nature were "nature", "green exercise", "virtual reality (VR), "immersive virtual nature", "digital nature".

The inclusion criteria for studies in the review were (1) studies conducted in an indoor setting (2) studies that presented visual stimuli and non visual stimuli (3) pee-reviewed journal papers and review articles. The exclusion criteria were (1) abstract-only articles and (2) psychological architecture indicator-lacking articles.

RESULT AND DISCUSSIONS

1. Non-physical Boundary Connecting Nature in a Windowsless Interior Space

Humans will try to control the interior space and make the space comfortable according to themselves (McCarthy, 2005). Nature is one aspect that humans will choose to make their space comfortable for their life processes, including their well-being (Wilson, 1984). In "NATURE", humans are included in it and "interior space" is one of the spaces surrounded by this nature (see Figure 2).
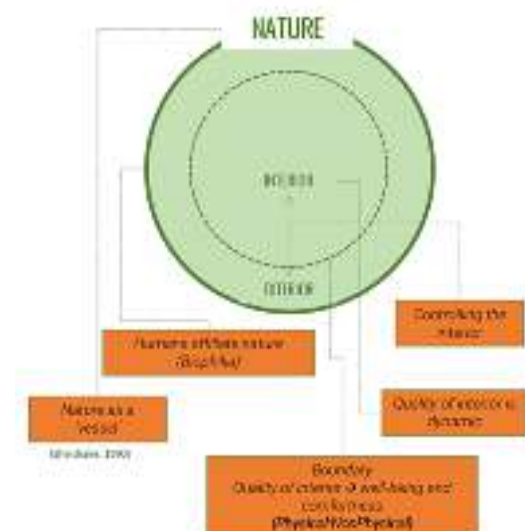
Figure 2. Diagram communication about the relationship between nature and interiority.
(Source: Personal Diagram)

The relationship between humans and nature is a necessity that humans do not knowingly or consciously do to always present nature in their lives. The relationship between human and nature also happens in the space that accommodates his daily activities. Including the interior space, which generally accommodates humans to spend more than 90% of their time (Lee & Chang, 2000). The notion of the interior from the exterior by looking at the quality of control humans have as users (Millar, 2010).

Controlling space with the role of nature sees the "boundary" conditions or boundaries that divide between the interior and the exterior. The conditions of the boundary determine flexibility, mobility, and the level of interiority in the interior space (McCarthy, 2005). McCarthy (2005) also opines that the boundary is part of the elements in the interior because in the boundary, there is a negotiation between the interior and the exterior. To present nature in the interior space that accommodates users when working, namely through boundaries, and boundaries can be both physical and non-physical (McCarthy, 2005).

The physical boundary is a limit that can make the quality of the interior space imaginable because it can be arranged with a structure (Millar, 2010). This is in the form of openings such as windows, doors, vents and holes that connect outdoor to indoor. Meanwhile, the non-physical boundary category can be something in intangible things such as human habits and behavior in presenting nature into its interior space (Millar, 2010).

Feeling nature becomes a quality that supports a comfortable space for humans by using the senses. This is because sensory processes are an essential way of experiencing space and mediating transactions between the human body and its space (Yatmo & Atmodiwirjo, 2013) . What the senses perceive in the room is called the atmosphere. "Atmosphere provides a sense of interior agency; the possibility that the ephemeral and visually immaterial might construct interiority in it's terms" (2005, p.11); according to McCharty, the atmosphere has a sense of interiority that creates interiority or quality in space.

Then how can nature support this if the interior space where the human being works does not have a physical boundary such as a window that connects nature to his working space? Especially in the COVID-19 pandemic, which causes the habit of staying in indoors so that some workers and students do their work remotely. This further reduces the connection between humans and nature because they cannot get close to nature. Nature is hampered to become an element of the interior space. Especially in the workspace, this is mentioned by Croome (2001) in his book entitled "Creating the Productive Workplace"

that the case of working spaces without windows is a problem of work space.

However, because the quality of interior space is not something static, nature can still influence it across these non-physical boundaries. Its role is to continue nature to become part of the interior elements that affect the quality of dynamic space following humans as controllers (McCarthy, 2005). The few gaps or openings that "open", then the experience of space will also change and this will happen every day. These conditions indicate that change will always occur at the boundaries. Boundaries that are not physically tangible, flexible according to human needs, and always able to connect aspects such as nature are the determining elements of the quality of interior space. Based on this, the most important thing is not the shape but the quality that shows the boundary mechanism to connect nature to it (see table 1 for a list of some boundary mechanisms).

Table 1. Boundary Mechanism

Mechanism	Definition	Source
Connectivity	Gaston Bachelard (1969) also explains in his book The Poetics of Space by likening boundaries as lace, that boundaries are unending series of connections, surrounding, but not enclosing space, forming boundaries and affording access.	(Millar, 2010)
Boundaries determines the quality aspects interior space	She explained by quoting what was shared by the Japanese architect, Shigeru Ban. Ban explained that boundaries do not have to be tangible, static, and he eliminates visible properties because boundaries can still create experiences from limitless space. "The opacity, the transparency, the light, the shadow are all factors drawing us in…." (2010, p. 174). Japanese artist Machiko Agano in his book Scuama in Ingold (2008) also explains that boundaries also carry a narrative or story, are more related to the human body itself, and can be developed in the context of spatial configuration.	(McCarthy, 2005), (Millar, 2010)

Boundaries can change based on time, events, and actions of the humans	The conditions of changing boundaries based on time and events are also explained by Tscumi (1990), "There are no space without events ..." and Blauvelt (2011), "Everyday act presence of space." This is always done in behavior or behavior in order to meet the needs of his daily life.	(McCharthy, 2005)

2. Nature Support Affective Well-being in Biophilic Design

Many issues regarding well-being and mental psychology have emerged due to the COVID-19 pandemic. Researchers suggest that this causes boredom and mental disorders because we spend all of our time indoors (Xiong et al, 2020). Stress due to WFH is also caused by aspects of fear of COVID-19 and anxiety of leaving the house, especially if the work and school environment is still not following health protocols (Tan et al, 2020).

Apart from this, work and schools that are held online also raise issues regarding mental health. Some reported increased depression and anxiety disorders due to e-learning (Tee et al, 2020) (Cao et al, 2020) (Fawaz & Samaha, 2020). Other research also records an increase in feelings of functional impairment, boredom, stigma, worry, phobia, frustration, and anger (Tee et al, 2020) (Ahmadi & Ramezani, 2020). This situation requires social and emotional support such as increased perceived threats to well-being and feelings of fear, isolation, uncertainty (Tee et al, 2020).

Based on this, the authors focus on emotional support a temporary condition that is felt and is a form of affective well-being or AWB (Kahneman &Deaton, 2010). AWB is a new form of hedonic well-being and is well-being that can be affected by environmental conditions including nature (Eger & Maridal, 2015). Environmental conditions that affect one's well-being are also discussed in biophilia and manifested by biophilic design in its design domain. In biophilic design, it also discusses 14 patterns of natural connectivity in design that influence on the health and well-being of its users. The author only focuses on the category "Nature in the Space" because this category connects nature directly. In this category has 7 patterns that show some important aspects of the biophilic design itself. From the 7 patterns, we conclude several patterns that can be combined. (see table 2).

Table 2. Important Aspects of Nature in The Space (Category of Biophilic Design)

Mechanism	Pattern in Biophilic Design	Source
Connectivity	Visual Connection with nature (Pattern 1), Non - Visual Connection with Nature (Pattern 2), and connection with natural systems(Pattern 7).	(Browning et al, 2014)(Kellert et al, 2008)
Variability and Presence of Natural Elements	Thermal and Airflow variability(Pattern 4), presence of water (pattern 5), dynamic and diffuse light (pattern 6)	(Browning et al, 2014)
Human Behavior	Non-Rhythmic Sensory Stimuli (Pattern 3)	(Browning et al, 2014)(Kellert et al, 2008)
Natural Moments and Their Stimulation	Non-Rhytmic Sensory Stimuli (Pattern 3) and Connection with Natural System (Pattern 6)	(Browning et al, 2014)

Apart from design, many studies discuss the benefits of nature on human emotions. Even in the field of psychology itself, nature relatedness has been linked to better emotional conditions and improves mood (Browning et al, 2020), the effectiveness of awareness (mindfulness)(Choe et al, 2020), hedonic "feeling good" and eudaimonic "functioning well" (Pritchard, 2020). Nature also has several benefits for the human body as well. In several existing studies, there has been much discussion about the strong relationship between the influence of nature on cognitive abilities (Mehta et al, 2012), concentration (Hartig et al, 2003), mood (Browning et al, 2020) (Hartig et al, 1996), memory (Felly & Susanto, 2020), comfort, well-being, and their productivity (Browning et al, 2014).

Regarding emotions themselves, there are main theories that discuss the concept of emotion, namely the theory of discrete emotions or basic emotions (Ekman, 1992) and the circumplex model of affect (Russel, 2003). The theory of basic emotions identifies human emotions in particular and reveals that each emotion has its own unique characteristics. Unlike the basic emotion theory, Russell's (2003) theory explains that humans have different core emotions and can be grouped into two emotional quadrants, valence and arousal. Valence leads to a psychological state consisting of pleasure poles, namely positive emotions

and displeasure (negative emotions). At the same time, arousal refers to the physiological (physical) state of humans which is described in terms of the active and passive poles. This emotion is called core affect (Russel, 2003).

Biophilic design is a popular form of sustainable building design because of its potential to contribute to human health and wellbeing. However, sustainability nowadays, especially sustainable design tends to focus more on avoiding the impact of damaging the environment or what we call 'low environmental impact design'. This condition has neglected the relationship between humans and nature, which is fundamental and essential (Kellert et al, 2008). There are still many green assessments that exclude this aspect of their assessment (McDonough & Braungart, 1992).

The impact of this is one of the conditions in which space was built without openings (See figure 1). Overhauling the finished design will cost money and add to rubble, but leaving this situation will also affect the well-being of users and even their health. Based on this already established but urgent situation, an idea emerged from another biophilic design pattern, namely the "15th pattern: virtual connection with nature" for spatial conditions that cannot access nature such as underground and windowless space.

The same statement was also stated by Browning et al (2020) that exposure to nature in virtual reality (VR) could support increased emotional well-being for people who cannot access the outdoors. Although the "15th" effect pattern is also said to be weaker than the "1st" pattern, which is a "direct connection with actual nature", virtual relationships with nature can still be generated through means that are mediated by natural simulacrums, living systems, and natural processes (Downton et al, 2016).

3. Non Immersive Virtual Nature as a form of non-physical boundary

This virtual technology idea has many opinions and contradictions, especially related to sustainability as a research field itself. Discussions about virtual nature technology as a solution to substitute for real nature has been discussed in several studies. One of them is the research of Litleskare et al. (2020) in their journal entitled "Enable, Reconnect and Augment: A New ERA of Virtual Nature Research and Application". Connecting with the natural environment can indeed improve health and well-being, in addition to a sense of a tendency to connect with nature as described in the biophilia theory itself, this is also due to promoting a feeling of 'away' from daily busyness, positive emotional reactions, and stress reduction (Litleskare et al, 2020).

However, Litleskare et.al (2020) research has a hypothesis that virtual nature may have a more positive impact on society than just being a substitute for real nature (Litleskare et al, 2020). This also explains that virtual nature can provide additional benefits from real nature (enable), help people reconnect with the real natural world (reconnect), and increase human-nature interactions (augment) (see table 3).

Table 3. Example of Enable, Reconnect, Augment of Virtual Nature Research and Application

| Mechanism	Examples (Research)	Source
Enable: Virtual Nature as a Supplement to Real Nature	Stress management at work–According to the European Agency for Occupational Safety and Health [56], work-related stress is one of the biggest health problems related to work-related health. Interestingly, a recent literature review highlighted the stress reduction effects of indoor nature exposure (an indoor environment that contains real or representations of nature-based stimuli involving multiple senses) and emphasized that health benefits from indoor nature exposure occur. by facilitating reduction and recovery from stress.	European Agency for Safety and Health at Work (2018). (McSweeney et al, 2019)
Reconnect: Virtual Nature as a Strategy to Reconnect People to Nature	A recent meta-analysis showed that individuals who report higher levels of nature connectedness tend to experience higher levels of positive affect, vitality and life satisfaction compared to those less connected to nature. Mayer et al (2009) found that participants' sense of connectedness to nature was improved after watching short videos of pleasant natural environments, with patterns that were	(Capaldi et al, 2014); (Maye et al, 2009)

	similar, although with a smaller effect-size, to an actual walk in real nature.	
Augment: Virtual Nature to Boost the Benefits of Human-Nature Interaction	Virtual nature experiences may be designed in a way that users may not only enjoy a pleasant walk in nature, but could also, for example, learn about biodiversity, its importance and how it can be protected.	(Shanahan et al, 2019)
	Nature-based interventions can not only provide an opportunity for the experience of nature but can in addition provide specific learning on psycho-social skills or sustainability which can optimize future human nature interactions	

This virtual nature technology itself has several types based on the form of application. This is also associated with Virtual Reality (VR) and Virtual Nature (VN), which have different definitions. VR is a medium that consists of an interactive computer simulation that senses the participant's position and actions and replaces or adds feedback to one or more senses, giving a feeling of being mentally immersed or present in the simulation (virtual world) (Sherman &Craig, 2003). An important characteristic of VR is that there is a disconnect between the user and the original environment, and it is necessary to use an HMD (Head-mounted Display) or "Google VR" to experience it. This technology is also known as Immersive Virtual Nature (IVN), which supports the illusion of being close to the natural environment (Calogiuri et al, 2019).

This concept relates to the 'psychological feeling' regarding the taste being transferred from a physical location to a virtual location. IVN is also considered to have a more interactive effect, more dynamic, more 'life-like', which is a real feeling so that it gives a sense of connection with nature (Litleskare et al, 2020). However, this technology cannot be experienced by everyone. This is because the application of this technology must use HMD and not everyone can use it. Moreover, HMD cannot be used for daily needs. Because of this, there are other virtual technologies whose applications are even easier to use for people's daily lives. This technology can also be used for the same purpose as IVN but with a blend of Non-

Immersive Virtual Reality (Non-IVN) reality (Litleskare et al, 2020) (see Figure 3). The higher level of the immersive virtual system also has side effects for users, namely cyber sickness. Cyber sickness is a symptom arising from a sensory conflict between visual, vestibular (balance) and proprioceptive (perceived stimuli related to body position and movement) signaling (Reason &Brand, 1975).

Other studies also show that human interaction with nature using this technology provides more health and well-being benefits than no connection at all to nature (Litleskare et al, 2020). However, the effect is less than natural exposure. Because of this, this solution is a solution that is only used for **really urgent conditions.** This is also related to sustainability behavior, which concerns that this technology does not link but closes the relationship between humans and the natural world. However, based on what is explained by Litleskare et.al (2020), namely that the three aspects of this virtual technology are **enabled, reconnect, and augmented**, maybe we can focus on their benefits for urgent situations such as windowless room (Litleskare et al, 2020).
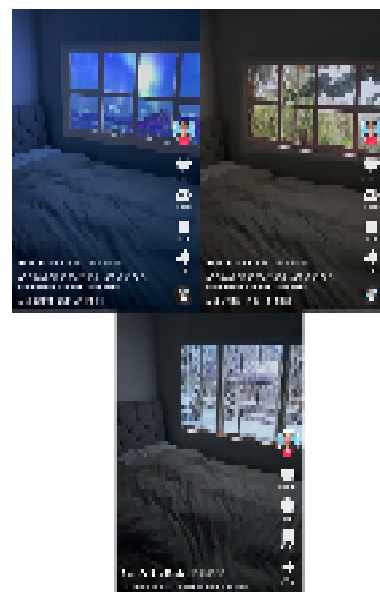

Figure 3. Fake Window trends in Windowless rooms that using one kind of Non-IVN Technology.
(Source: Screenshots from TikTok Videos uploaded by @thejunglebadger)

So in their research, Litleskare et.al (2020) only focus on VN technology; (1) allows us to extend the positive effects of natural interactions when we have left the natural setting outdoors; (2) provide access to nature for individuals who may not be able to access it directly; (3) increases feelings of connectedness with nature and; (4) raises greater awareness of environmental and sustainability issues.

Based on the explanation above, a windowless room, especially space where humans are working, needs this solution so that they can stay in touch with nature. The author also focus on Non IVN because it does not cut the relationship between residents and their natural environment. This technology is also easier to integrate in everyday human life. It is more in line with the nature of boundaries that change based on time and events that are regulated by humans as users themselves.

Studies have discussed the effect of VN technology on psychological aspects such as reducing stress(Hedblom et al, 2019), increasing stress healing(Hedblom et al, 2019), emotional reactions(Dieme et al, 2015), mental health[10], relaxation effects (Gerber et al, 2019), reduction of anxiety (Selhub & Logan, 2012) etc. This conditions supports VN technology for human contexts who are currently spending all their time at home for WFH and experiencing stress and decreased emotions and moods as previously described.

Based on boundary mechanism and important biophilic design aspects, both can be realized by Non-IVN technology. This is because this technology also has several important aspects or characteristics that affect the mechanism in connecting nature. This technology can connect multisensory nature even though virtually (Hedblom et al, 2019). Many types of technology present nature visually (images, 360º images, video) and non-visuals such as audio (natural sounds, natural instruments, bird sounds) (Litleskare et al, 2020) (Hedblom et al, 2019). This technology is also created and can be set according to the purpose of user (Browning, et al) (Choe et al, 2020) like we can choose what kind of natural scenery we want to watch. This nature can become part of the interior elements if the type of technology used is non-IVN (video screen on wall, video projection). Because humans themselves can regulate this technological system, this technology can bring narratives according to human needs and follow their habits. (Browning et al, 2020) (Litleskare et al, 2020) (See diagram 1 for important aspects of Non-IVN technology) (see Figure 4).
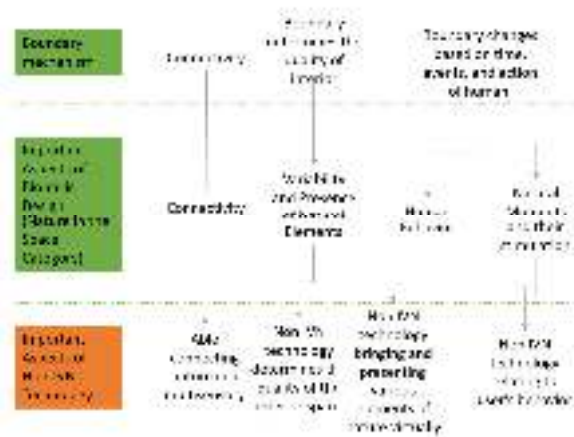
Figure 4. Diagram communication about the synthesis of Non-IVN Technology as a "boundary" that able to realize biophilic design in windowless room.
(Source: Personal Diagram)

CONCLUSION

Based on the literature explanation regarding the three main theories above, it can be concluded that virtual nature technology is a form of reconnecting nature for those who cannot access it. Its nature that can connect nature back into an interior space that does not have physical openings such as windows makes this technology a non-physical boundary that can emotionally connect nature. Several aspects can realize the boundary mechanism as an element. The virtual nature mechanism as a boundary that connects nature in a windowless space, namely; 1. Connecting nature with various sensory forms (multisensory). VN can provide nature in various forms of stimuli such as visual, auditory, tactile, and spatial influences with advances in technology. 2. Determining the quality of interior space, because the shape can be determined by the human designing it, VN content can be designed in such a way as to form interior elements in what form. 3. Bringing and presenting the diversity of aspects of nature, the nature shown by this technology can also be selected or narrated according to the needs and desires of its users. This is related to the 4th mechanism, which is related to the user's habits. When and how the shape of the VN can be adjusted by the user himself later.

Regarding the emotional relationship of this technology, further research is needed to find out what kind of VN technology application can increase the most optimal emotions in the future.

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