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Unveiling the key determinants and consequences of Virtual Reality in the immersion experience

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Abstract. *In recent years, there has been significant advancement in virtual reality (VR) technology development. VR headsets have become lighter, offer higher resolution, and possess more powerful computational capabilities. Previous research has indicated that the level of immersion in operating technological products can positively impact user experiences. This study explores the effects of interaction, vividness, embodiment, and media novelty on immersion, perceived usefulness, satisfaction, and continuance intention. This study collected data from 150 users of virtual reality devices with the help of a survey methodology and analyzed the data with the help of the Partial Least Square – Structural Equation Model (PLS-SEM) technique. The results indicate that interaction and vividness do not directly influence immersion. However, embodiment and media novelty indirectly affect perceived usefulness, satisfaction, and continuance intention by increasing immersion. Our findings underscore the importance of embodiment and media novelty for users in virtual environments. When users can experience a genuine sense of embodiment and novelty in the virtual environment, their perception of usefulness, satisfaction, and intention to continue using VR is enhanced. These results provide valuable guidance for designing and applying virtual reality, aiming to improve user experiences and continuance intention. This study contributes to analyzing the antecedents and consequences of immersion and offers insights that can assist academic research, VR-related development, and businesses' marketing efforts.*

Keywords: Interaction; Vividness; Embodiment; Media Novelty; Immersion; Perceived Usefulness; Satisfaction.

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Introduction

Among the many technology trends, Virtual Reality (VR) is attracting the attention of global manufacturers, technology media, and consumers (Wedel et al., 2020). VR offers a virtual platform that allows the behavior of users in the real world to be reflected in the virtual environment through physical feedback, changing the communication platform for users to interact with the world and having considerable potential. The VR industry is now successfully involved in various subject areas, including education, military, e-commerce, audio-visual entertainment, healthcare, real estate, and engineering design, and has significantly impacted how people use technology products (Su et al., 2020). However, even though VR has a wide range of applications, it is still relatively niche compared to users of mobile devices such as smartphones and tablets (Wu, 2019). As the VR industry market has reached saturation under the active investment of hardware and software developers, industry players should not only consider the specifications of VR hardware devices but also use the depth of application content as an indicator and conduct empirical surveys on specific customer segments through differentiation. The challenge is how to get users to engage with the value proposition through VR and how to market their products and ideas. Previous studies on VR have presented many examples of VR applications that allow users to focus on the interaction of virtual reality scenes and empirically demonstrate the factors associated with the continued use of virtual environments (Barnes, 2011; Goel et al., 2011; Jung, 2011; Verhulst et al., 2017), but these studies have paid little attention to the differences in the level of focus of different application types of virtual reality scenarios.

In the dynamic landscape of virtual reality (VR), the concept of immersion stands as a pivotal element, redefining the nature of user engagement and experience (Verhulst et al., 2017). Immersion in VR refers to the extent to which users perceive a seamless integration into a computer-generated environment, blurring the lines between the physical and the virtual. As users wear VR headsets and enter these digitally designed realms, the importance of immersion becomes increasingly pronounced. It is the catalyst that transforms VR from a mere technological novelty into a powerful medium capable of eliciting profound emotional, cognitive, and behavioral responses (Manis & Choi, 2019). The immersive quality of VR experiences is not solely confined to the visual realm; it encompasses the entirety of sensory inputs, drawing users into an alternate reality where they can interact, explore, and navigate. Understanding the determinants and consequences of immersion in VR is paramount, as it not only shapes the efficacy of virtual environments, but also has implications for fields ranging from education and healthcare to entertainment and beyond (Matovu et al., 2023; Su et al., 2022). This research seeks to unveil the key factors influencing immersion in VR and unravel the multifaceted consequences that ensue, contributing to a nuanced comprehension of the transformative potential inherent in immersive virtual experiences. Therefore, this study will take commercial marketing as the main axis to explore whether VR platforms have immersion in the sales of products or services and understand the differences in the user experience of VR devices through the actual immersion of different uses of VR in order to provide a reference for the industry to make decisions and develop marketing policies in the future.

In the past, industry marketing was about building customer relationships through physical interaction in the field. VR technology provides an environment that allows users to search for information through multiple sensory modalities, such as vision and hearing, and to perceive the real performance of the environment they are shaping through interaction.

This study will use VR devices as a representative of innovative technology and use VR users as experimental subjects to conduct experiences in different contexts to further investigate the following objectives:

- Whether there are significant differences in the immersion of the subjects in different types of VR application contexts.
- The determinants of VR in the immersion experience
- The impact of VR immersion on the users continuous usage intention.

Literature review

Virtual reality

The concept of virtual reality is to use computer processing to generate a three-dimensional virtual space, allowing users to simulate visual, tactile, and auditory senses to obtain an immersive experience, which is a brand-new way of human-computer interaction (Matovu et al., 2023; Steuer, 1992).

The literature on Virtual Reality (VR), immersion, and related topics offers a wealth of perspectives on the complex landscape of this evolving technology. Scholars have delved into the technical aspects of VR, exploring advancements in hardware and software that enhance immersive experiences (Matovu et al., 2023; Vondráček et al., 2023). Furthermore, a thorough review has revealed a nuanced understanding of the psychological and perceptual mechanisms underlying VR immersion, shedding light on users' cognitive processes and emotional responses (Kim et al., 2023). Various studies in this literature have investigated how design elements, such as visual and auditory cues, impact the level of immersion achieved. Additionally, researchers have explored the influence of user characteristics, such as prior experience and individual differences, on the immersive quality of VR interactions (Mäkinen et al., 2023). By synthesizing this diverse range of research, this study aims to build upon existing knowledge and offer new insights into the factors influencing immersion outcomes within the VR domain.

In the past, Burdea & Coiffet (2003) proposed the I3 characteristics of virtual reality, which are Immersion, Interaction, and Imagination, and the definitions of I3 are explained below:

- Immersion: It refers to the virtual reality in which users get the same visual, auditory, and other sensory experiences as in the real environment so that users can immerse themselves in the virtual environment and generate a sense of immersive presence (Del Aguila et al., 2021; Su et al., 2022).
- Interaction: This means that users can interact with various objects in the virtual environment through input and output devices, allowing them to receive the same feedback as in real life.
- Imagination: In the virtual environment, users can imagine the information that is not directly presented in the virtual environment through the process of logical judgment, association, and reasoning and further generate new ideas.

In addition to common video games, it also covers the fields of education, healthcare, industrial design, and military affairs, demonstrating the potential of VR technology and development. Pandrangi et al. (2018) produced 3D models of tomographic scans of patients with abdominal aortic aneurysms to give patients a full understanding of their health status through a VR device. Bashabsheh et al. (2019) applied VR technology as a tool in architecture

courses and proved to be more effective than traditional teaching methods. As for e-commerce, a study by Van Kerrebroeck et al. (2017) pointed out that VR technology can help customers enjoy their consumption during peak crowded conditions in the outlets. Meißner et al. (2019) combine eye-tracking with VR technology to help consumers assist in the selection of products, more closely matching the actual purchase behavior. The virtualization technology of VR goes beyond the previous images of products on the shopping plane and allows products to jump directly into reality, allowing users to experience products through a three-dimensional virtual reality effect (Verhulst et al., 2017). The development of VR has given birth to new forms of audio-visual entertainment and broken the physical limitations of space, and applications will continue to grow in the future.

Immersion

The term immersion is often discussed extensively in the technological literature and can be used to assess the degree of attention people pay to various information systems, physiologically and psychologically (Carù & Cova, 2006). In a previous study, Csikszentmihalyi (1990) referred to this phenomenon as Flow Theory, which suggests that when an individual is fully engaged in the activity at hand, the user enters into a common mode of experience where irrelevant perceptions are filtered out, and even cut off from reality in order to respond to immediate goals and feedback. The most important elements include immediate feedback, a sense of potential manipulation, a sense of distortion in the temporal experience, a sense of concentration, the integration of behavior and consciousness, and a self-motivated goal (Csikszentmihalyi, 1993). Hansen & Mossberg (2013) define immersion as a psychological state in which an individual is in a stage of deep engagement. Many output devices, such as computers, television screens, or head-mounted devices, allow for different stages of immersion (Hudson et al., 2019).

Immersion has been used many times in recent years to explain the interaction between humans and technology. In an empirical study of online games, Snodgrass et al. (2012) suggested that the pleasure and challenges players get during the gameplay process will make them more immersed in the online game experience. Merchant et al. (2014) suggest that the use of VR-related games, contextual simulations, and other tools to immerse students in the teaching and learning environment can have a positive effect on improving learning outcomes for users from higher education backgrounds. This study will use users of virtual reality devices as the target population to investigate whether there are significant differences in the immersion of VR application environments, and the factors that cause immersion and subsequent effects.

Determinants of immersion in VR

The rationale behind choosing immersion determinants in virtual reality (VR), including interaction, vividness, embodiment, and media novelty, lies in their fundamental role in shaping user experiences and enhancing immersion within virtual environments. These determinants were selected for their combined impact on users' cognitive, perceptual, and emotional responses to the virtual realm. This ultimately influence the overall depth of immersion and sense of presence experienced by users.

Interaction

Interaction is a set of physiological behaviors and responses of the human individual. According to Heeter (2000), all kinds of human behaviors involve interactivity, including reflections between people and people, between people and their environment, and between people and tangible or intangible (e.g., light, sound) objects around them. With the advancement of information technology and digitalization, companies and customers can use the integration of hardware and software as a medium to achieve marketing strategies through interaction.

In recent studies related to technology media, interaction is often used as a key indicator, and Kim et al. (2015) showed that users' satisfaction with cell phone features, systems, and compatibility is positively affected by interaction. For e-commerce, Barreda et al. (2016) in their study of online branding, suggest that the interactivity of the online network leads to good brand image and awareness, which in turn drives brand value, while Wu (2019) argues that highly interactive online retail sites positively influence attitudes towards products.

With the rapid development of virtual reality technology, interactivity can give users a similar feeling to the real environment. Research related to Human-Computer Interaction also often explores the interaction between human and virtual reality, bringing positive benefits through natural and effective interaction patterns in virtual environments (Yang et al., 2019).

As per McMillan & Hwang (2002), virtual reality's interactivity comprises three viewpoints: Telepresence, Process View, and Perceptual View. The Telepresence Perspective underscores immersion within the virtual environment, highlighting users' depth of engagement and authenticity (Steuer, 1992). Conversely, the Process View Perspective examines user-environment interactions, including input, system responsiveness, and engagements within the virtual domain (Burdea & Coiffet, 2003). Lastly, the Perceptual View Perspective delves into sensory and cognitive aspects of virtual interactions, exploring users' perception and incorporation of sensory cues, including realism, fidelity, and integration of multiple modalities (Cheng et al., 2014). Cheng et al. (2014) argue that interactive performance is useful for understanding the evaluation of user effects after the virtual reality has been implemented. This study incorporates interactivity as a prefactor in virtual scenes to investigate whether interactivity enhances the immersion experience of virtual reality scenes.

Vividness

Vividness is a quality generated by internal experience, also known as media richness (Daft & Lengel, 1986), which is the perceived and emotional characteristics of a technology product and its features after the user has experienced it for the first time (Xu et al., 2021). In virtual reality, vividness reflects the intensity, clarity, content richness, and lifelike sensory properties of the subjective impression of virtual reality (Cheng, 2014). According to Mazzarol et al. (2007), messages are more influential when they are presented in a more lively and vivid form and are more likely to influence consumers' re-dissemination intentions and behaviors. This study incorporates vividness as a predictor in virtual scenes to investigate whether vividness enhances the immersive experience of virtual reality scenes.

Embodiment

Embodiment is the sense that users imagine as an extension of their own senses and can intuitively operate and accomplish desired goals in the context of using technological products (Dell'Anna et al., 2018). Banakou et al. (2016) argue that immersion is a virtual representation of being a different person from oneself through virtual characters. The embodiment has been used as a proxy for presence in previous studies on virtual reality, but Herz et al. (2019) argue that there is a difference between embodiment as being in a different environment and presence as being a different individual. This study incorporates the embodiment as a prefactor for virtual scenes to investigate whether the embodiment enhances the immersive experience of virtual reality scenes.

Media novelty

Media novelty embodies a quality of freshness, uniqueness, and divergence from preceding encounters. As users engage with novel media innovations, their initial reactions typically reflect enthusiasm and curiosity. However, through recurrent exposure to such novelties, the initial allure diminishes over time, resulting in consumer adaptation. As users acclimate to the novelty, the initial fervor subsides, potentially diminishing the innovation's significance. The stimulation of new technology products affects people's decision-making process and ignores the stimulation of previous technology products compared to the similarity of general technology products.

In past empirical studies, the benefits of media novelty have been shown to influence subsequent behavioral intentions. In a museum education and learning study, Sandifer (Sandifer, 2003) showed that exhibits with openness and technological novelty caused visitors to spend more time in dwelling actions. In the context of social media, the novelty value of social media has a positive effect on their attitudes toward use (Xie et al., 2021; Xu et al., 2021). Therefore, this study incorporates media novelty as a pre-requisite for virtual scenes to investigate whether media novelty enhances the immersive experience of virtual reality scenes.

Perceived usefulness

In the past, the Expectation Confirmation Model (ECM) has been widely used in user behavior research to investigate the perceived usefulness of products and services, explaining that after using a product or service, users compare the performance of the process with their expectations before using it, in order to measure their satisfaction after using the product or service and influence their subsequent intention to use it (Bhattacherjee, 2001; Zhao & Khan, 2021). Perceived usefulness is the extent to which users perceive their work or life to be improved by using the information system (Chen et al., 2013; Chen et al., 2009; Liao et al., 2007).

Perceived usefulness is often used to explore and interpret the literature related to innovative technologies. Weng et al. (2017), in a study of cab calling apps, indicated that users' attitudes towards the use of the app were positively influenced by the ease of use of the app, which made it quicker and easier to call a cab. Mouakket (2018) included personality traits as antecedents of perceived usefulness to explain how these traits affect Facebook usage intentions.

Although there are many applications of virtual reality, there are few empirical studies on the causal relationship between immersion experience and perceived usefulness.

Therefore, this study will investigate whether the immersive experience of users' virtual reality scenes enhances the perceived usefulness.

Satisfaction & continuance intention

Satisfaction refers to the expected level of satisfaction based on the satisfaction standard generated from past experiences, and the result of the satisfaction level felt after the service compared to the expected satisfaction standard has a positive impact on the attitude to using the information system (Chen & Lin, 2019; Thong et al., 2006). Many studies on marketing and information systems use satisfaction and intention to use as important indicators to determine whether customers will continue to use the product or service. For example, Tsaur et al. (2007), in a study of visitor experiential marketing in Taipei City Zoo, pointed out that visitors' satisfaction with experiential marketing directly affects their behavioral intentions. The study by Kim et al. (2015) related to smartphones found that consumers' satisfaction with the quality of use of the phone drove them to continue using the phone and the carrier providing the service. In a study of augmented reality combined with e-learning, Liu (2015) also concluded that user satisfaction is an important factor in whether users will continue to use augmented reality for e-learning.

Since the willingness of users to continue using VR services is a key success factor for service providers, it is also important to understand the elements of VR users' willingness to follow up. Therefore, this study will investigate whether users' perceived usefulness after experiencing VR scenarios enhances their satisfaction and continuance intention.

Research method

Development of research hypotheses

In a study of virtual reality scenarios, Cheng et al. (2014) found that users interacting with surrounding objects in the environment enhanced the immersion experience. In a study of augmented reality, Yim et al. (2017) noted the significant impact of user interaction and vividness on the immersion experience, in addition to the novelty of the new technology, which also enhances the experience of immersion. According to Herz et al. (2019), immersion in virtual reality scenarios also significantly impacts the immersion experience. Based on the above-related literature and derivations, the following research hypothesis is proposed in this study:

H1: Interaction with the VR scenes experienced by users has a positive impact on immersion.
H2: Vividness of the VR scenes experienced by users has a positive impact on immersion.
H3: Embodiment with the VR scenes experienced by users has a positive impact on immersion.
H4: Media novelty of the VR scenes experienced by users has a positive impact on immersion.

An empirical study by Novak et al. (2000) found that the higher the immersion of online users, the higher their usage behavior. It was also found that users' mind-flow experiences positively influenced their evaluation of hedonic performance (Ozkara et al., 2017). Yim et al. (2017) also pointed out the positive relationship between immersion and cognitive usefulness. Based on the above-related literature and derivations, the following research hypothesis is proposed in this study:

H5: Immersion of the VR scenes experienced by users has a positive effect on perceived usefulness.

H6: Immersion of the VR scenes experienced by users has a positive effect on satisfaction.

According to Oliver & Desarbo (1988), the higher the user's expectation (perceived usefulness) of the system, the higher the satisfaction level. The expectation confirmation theory proposed by Bhattacherjee (2001) also describes that cognitive usefulness has a positive effect on satisfaction and intention to use, and that good satisfaction also increases users' intention to use. The positive effect of users' cognitive usefulness on satisfaction and continued intention to use has also been found in past studies related to technology media (Gan & Li, 2018; Hooi & Cho, 2017; Mouakket, 2018; Nascimento et al., 2018). Based on the above-related literature and derivation, the following research hypothesis is proposed in this study:

H7: Perceived usefulness of the VR scenes experienced by users has a positive effect on satisfaction.

H8: Perceived usefulness of the VR scenes experienced by users has a positive effect on the continuance intention.

In a study by Hong et al. (2017) on smartwatches, it is suggested that the degree of utilitarianism of users in handling technology products positively influences the intention of continued use. Mouakket's (2018) study on social media and personality traits also indicates that users' intention to continue using is judged by how satisfied users are with the technology products they use. Previous studies have confirmed that user satisfaction with operating technology products has a positive relationship with continued usage intention (Cheng et al., 2015; Rose et al., 2012). Based on the above-related literature and derivations, the following research hypothesis is proposed in this study:

H9: Satisfaction with the VR scenes experienced by users has a positive effect on the continuance intention.

Integrating the above-mentioned structural aggregation and hypothesis derivation, the following research model is proposed in this study, as shown in Figure 1. The operational definition and the questions of the example of scale items for each latent variable are shown in Table 1.

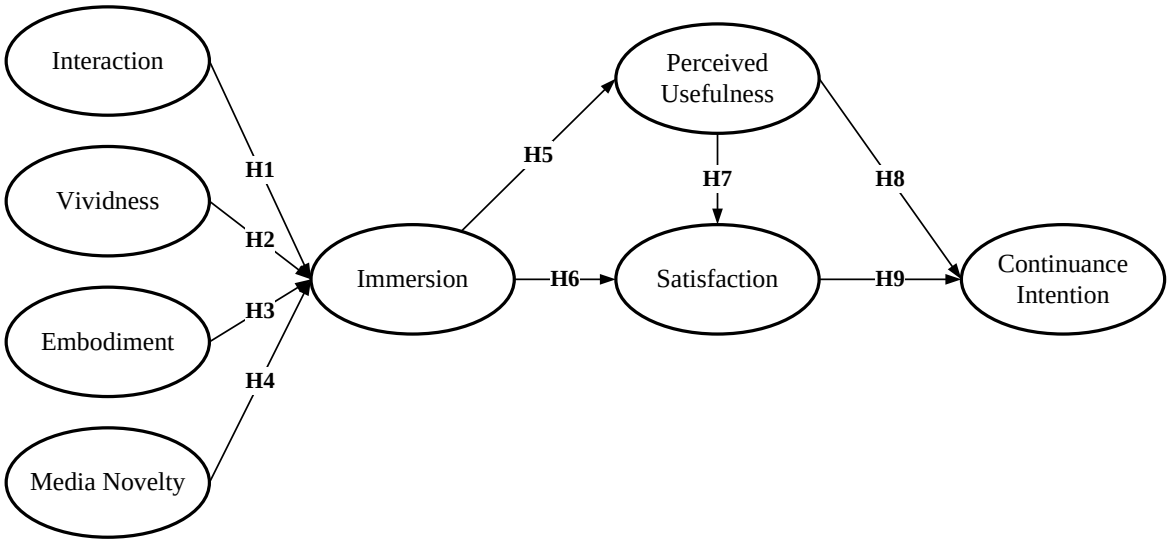

Figure 1. Research Model

Source: Authors' own research.

Table 1, Operational definition and scale item of latent variable

Latent variables	Operational definition	Example of scale item	Source
Interaction	When users are in the VR experience, they receive information about the surrounding scenes and respond accordingly.	The VR device responds effectively to my actions when I'm operating it.	Cheng et al. (2014); Yim et al. (2017)
Vividness	The intensity, clarity, and richness of the objects and scenes that users feel when they are in a VR experience.	In the VR situation, I feel that the surrounding scenes are detailed.	Yim et al. (2017)
Embodiment	When the user is in the VR experience, the level of commitment to their role and senses.	The VR context made me feel like I was in a different body.	Herz et al. (2019)
Media Novelty	The novelty, uniqueness, and degree of difference users feel when they are in a VR experience.	Overall, I think there is a difference between VR devices and traditional 2D environments.	Yim et al. (2017)
Immersion	When users are in the VR experience, the degree to which they ignore the external environment and the degree to which they focus on the content of the VR context.	I would be so focused on the virtual environment that I would ignore everything else.	Jennett et al. (2008); Hamari et al. (2016)
Perceived Usefulness	The extent to which the user perceives the VR device to be useful.	VR devices can help me with virtual travel status	Brooke (1996); Yim et al. (2017)
Satisfaction	The extent to which the user can use the VR device to satisfy the user's physical and mental needs after the VR experience.	Overall, I was satisfied with my experience with the VR device.	Bhattacherjee (2001); Mouakket (2018); Hong et al. (2017); Yim et al. (2017)
Continuance Intention	The intention of users to continue using VR devices in the future.	CI1: I would be willing to enjoy virtual travel with a VR device after experiencing VR.	Bhattacherjee (2001); Chen et al. (2015)

Source: Authors' own research.

Results

Demographic characteristics of respondents

In this study, users of virtual reality devices were used as the target population to investigate whether VR application contexts would have significant differences in the immersion of the subjects and the causal relationship of immersion.

The study utilized a virtual reality (VR) system provided by HTC VIVE, comprising the VIVE head-mounted display, wireless controllers, base stations, and associated accessories. Through the immersive experience facilitated by wearing the head-mounted display and

using the wireless controllers, participants were able to engage with a lifelike virtual environment, fostering a profound sense of presence within the scenes. This setup allowed users to interact with three-dimensional objects, enhancing experiential depth beyond conventional two-dimensional displays. A total of 150 participants took part in the experiment, each equipped with VR equipment and computers that met specified operational requirements. Before commencing the experiment, participants were provided with instructions by the research staff and had the opportunity to acquaint themselves with the VR equipment during a session lasting between 40 to 60 minutes. Following this, participants engaged in three distinct VR scenarios, each spanning five minutes, after which they completed a questionnaire. The study refrained from employing traditional survey methods, such as online surveys or face-to-face interviews, due to the necessity for participants to visit the research laboratory for training and familiarization with the VR interface, ensuring the validity of the data collected.

In this research the items to measure interaction were adapted and modified from Hongsuchon et al.'s (2023) and Gao & Boehm-Davis's (2023) research. Furthermore, vividness was measured based on the modified research items from Zhao & Khan's (2021) and Kim et al.'s (2021) research. In addition, the modified research items from Peck & Gonzalez-Franco's (2021) and Stinglhamber et al.'s (2015) studies were utilized to measure embodiment. Additionally, immersion was measured by the modified research items from Hamari et al.'s (2016) and Lee et al.'s (2013) research. Moreover, media novelty was measured by the items suggested by Tokunaga's (2013) and Yim's (2011) research. Perceived usefulness research items were adapted and modified from Xu et al.'s (2021) and Al-Adwan et al.'s (2023) research. Satisfaction was measured by the modified items adapted from Zhao & Khan's (2021) and Al Amin et al.'s (2023) research. Lastly, continuous intention was measured by the modified items suggested by Guo et al.'s (2023), Rahardja et al.'s (2023), and Zhao & Khan's (2021) research.

IBM SPSS Statistics 24 statistical tool was used to conduct descriptive statistical analysis, and the reliability, validity, and path analysis were conducted using SmartPLS 3.0. This study uses the Partial Least Squares (PLS) method for analysis and validation. Because the main function of Partial Least Squares is to explore and explain the structural model's structure, and the data allocation does not limit it, it is more suitable to handle the data with small sample size.

Based on the structural analysis of the sample, the mean age of the subjects ranged from 20 to 25 years old. In this study, the proportion of males and females was 56% and 44%, respectively, with males predominating. Regarding the use of 3C products, the proportion of those who use 3C products for more than 7 hours a day and those who use 3 hours to 7 hours a day are tied for the highest, accounting for 48%. As for the items that 3C products are frequently contacted, social media has the highest proportion of 91.6%, followed by audio-visual streaming and electronic games, with proportions of 70.8% and 66.6%, respectively.

In the survey on virtual reality devices, most respondents had experience with VR devices before this experiment, accounting for 72% of the respondents. At the end of the experiment, after confirming that all respondents had experience with VR devices and then considering the convenience, the survey of the factors that respondents focused on learned that when using VR devices to seek the most convenient operation, accounting for 32%, followed by the use of space range and portability, accounting for 28% and 24% respectively.

Outer model

The analysis software, SmartPLS 3.0, was used to conduct the measurement model analysis to assess the reliability and validity of the latent variables, followed by the path analysis to explain the inner model. In terms of validity testing, convergent and discriminant validity were used as the measures in this study. According to Fornell & Larcker (Fornell & Larcker, 1981), an average variance extracted (AVE) of 0.5 or higher for a construct is considered to have convergent validity (as shown in Table 2).

Table 2. Reliability and convergent validity

	Cronbach's Alpha	**Composite Reliability**	**AVE**
Interaction (INT)	0.81	0.87	0.64
Vividness (VI)	0.79	0.86	0.61
Embodiment (ENB)	0.96	0.98	0.96
Media Novelty (MN)	0.90	0.93	0.77
Immersion (IM)	0.89	0.92	0.74
Perceived Usefulness (PU)	0.79	0.86	0.61
Satisfaction (SAT)	0.96	0.97	0.85
Continuance Intention (CI)	0.94	0.95	0.84

Source: Authors' own research.

In terms of discriminant validity, it is based on comparing the factor loadings of each construct with the cross-loadings, and checking whether the factor loadings corresponding to its own construct are higher than the cross-loadings of other frames. As shown in Table 3, the factor loading is higher than the cross-loading of each indicator. This result represents the discriminant validity of the empirical data in this study.

Table 3. Factor loading and cross loading

Construct and items	**CI**	**ENB**	**IM**	**INT**	**MN**	**PU**	**SAT**	**VI**
CI1	0.86	0.45	0.34	0.30	0.59	0.50	0.60	0.48
CI2	0.93	0.55	0.51	0.37	0.65	0.57	0.67	0.49
CI3	0.94	0.56	0.49	0.43	0.72	0.57	0.75	0.46
CI4	0.94	0.54	0.54	0.40	0.72	0.50	0.77	0.42
EMB1	0.58	0.98	0.63	0.38	0.63	0.34	0.56	0.49
EMB2	0.55	0.98	0.55	0.37	0.65	0.30	0.59	0.48
IM1	0.48	0.62	0.84	0.40	0.56	0.36	0.56	0.51
IM2	0.51	0.49	0.88	0.30	0.55	0.36	0.61	0.42
IM3	0.41	0.47	0.84	0.30	0.57	0.43	0.51	0.38
IM4	0.39	0.50	0.89	0.31	0.45	0.45	0.53	0.33
INT1	0.26	0.24	0.17	0.61	0.35	0.28	0.35	0.36
INT2	0.36	0.38	0.44	0.89	0.46	0.30	0.55	0.51
INT3	0.37	0.30	0.26	0.84	0.42	0.26	0.44	0.45
INT4	0.31	0.25	0.21	0.83	0.38	0.25	0.38	0.43

Construct and items	CI	ENB	IM	INT	MN	PU	SAT	VI
MN1	0.72	0.65	0.52	0.37	0.88	0.49	0.74	0.60
MN2	0.69	0.62	0.50	0.43	0.91	0.47	0.72	0.57
MN3	0.51	0.43	0.51	0.55	0.79	0.41	0.72	0.53
MN4	0.66	0.60	0.58	0.42	0.93	0.49	0.73	0.54
PU1	0.47	0.24	0.37	0.29	0.43	0.86	0.41	0.37
PU2	0.52	0.43	0.34	0.35	0.48	0.74	0.53	0.40
PU3	0.28	0.03	0.24	0.08	0.17	0.71	0.26	0.15
PU4	0.48	0.22	0.45	0.26	0.46	0.80	0.51	0.34
SAT1	0.77	0.59	0.62	0.48	0.80	0.62	0.94	0.51
SAT2	0.77	0.56	0.58	0.56	0.80	0.50	0.94	0.50
SAT3	0.75	0.63	0.65	0.42	0.84	0.55	0.92	0.55
SAT4	0.64	0.49	0.52	0.56	0.68	0.51	0.91	0.45
SAT5	0.57	0.41	0.58	0.59	0.69	0.43	0.90	0.47
VI1	0.45	0.42	0.40	0.48	0.55	0.31	0.44	0.85
VI2	0.46	0.43	0.37	0.49	0.61	0.36	0.52	0.88
VI3	0.33	0.39	0.41	0.34	0.37	0.34	0.33	0.67
VI4	0.30	0.27	0.29	0.45	0.47	0.33	0.39	0.71
Note: Continuance Intention= CI; Embodiment= ENB; Immersion= IM; Interaction= INT; Media Novelty= MN; Perceived Usefulness= PU; Satisfaction= SAT; Vividness= VI								

Source: Authors' own research.

In order to further investigate the independence among the components in the research model and ensure the accuracy of the analysis results, this study analyzes the issue of whether the components have covariance by the variance inflation factor (VIF). If VIF is greater than 3 means that the components have covariance. The VIFs of interactivity, vividness, immersion, and media novelty were 1.538, 1.947, 1.780, and 2.351, respectively.

Inner model

The results of this study are shown in Table 4, which examines the validity of the hypothesis using the PLS examination study model path analysis. Among them, the positive influence of interaction and vividness on immersion has not reached a significant level, so it does not support hypotheses H1 and H2. The positive effect of embodiment and media novelty on immersion reaches a significant level, thus supporting hypotheses H3 and H4. The positive effect of immersion on perceived usefulness and satisfaction reached a significant level, thus supporting Hypotheses H5 and H6. The positive effect of perceived usefulness on satisfaction and Continuance Intention reached a significant level, thus supporting hypotheses H7 and H8. The positive effect of satisfaction on continued intention reached a significant level, thus supporting hypothesis H9.

Table 4. Results of hypothetical path analysis

Hypothetical Path	Path Coefficient	t-value	p-value	Result
H1:INT->IM	0.040	0.327	0.372	Not supported
H2:VI->IM	0.086	0.669	0.252	Not supported
H3:ENB->IM	0.334	1.888	0.030*	Supported
H4:MN->IM	0.325	2.220	0.013*	Supported
H5:IM->PU	0.464	3.401	0.000**	Supported
H6:IM->SAT	0.481	3.931	0.000**	Supported
H7:PU -> SAT	0.350	2.841	0.002**	Supported

Hypothetical Path	Path Coefficient	t-value	p-value	Result
H8:PU->CI	0.215	2.188	0.014*	Supported
H9:SAT->CI	0.642	6.840	0.000***	Supported
Note： * p-value <0.05; ** p-value <0.01; *** p-value <0.001				

Source: Authors' own research.

In this study, the values of R-square of the four endogenous variables of immersion, perceived usefulness, satisfaction, and continuance intention in the model were respectively 0.458, 0.215, 0.510, and 0.618, in other words, interaction, vividness, embodiment, and media novelty can explain 45.8% of the variation in immersion; immersion can explain 21.5% of the variation in perceived usefulness; immersion and perceived usefulness can explain 51.0% of the variation in satisfaction; perceived usefulness and satisfaction can explain 61.8% of the variation in continuance intention, as shown in Figure 2.

Figure 2: Analysis of the inner model

Source: Authors' own research.

In this study, we learned the direct relationship of each component by model path analysis, and then we will examine the effect of intermediary effect under the value of 90% asymmetric reliance interval by bootstrapping method. The results of the analysis are shown in Table 5, which shows that the mediation variables of each facet have their indirect effects.

Table 5. Results of indirect effect analysis

Mediation path	t-value	Bias-corrected percentile bootstrap confidence interval (90%)
ENB->IM->PU	1.943**	(0.075,0.269)
MN->IM->PU	1.540*	(0.041,0.296)
ENB->IM->SAT	1.838**	(0.058,0.274)
MN->IM->SAT	1.489*	(0.050,0.310)
IM->PU->CI	1.663**	(0.038,0.195)
IM->PU->SAT	2.947**	(0.114,0.249)
IM->SAT->CI	3.207**	(0.189,0.433)
PU->SAT->CI	2.575**	(0.116,0.337)
Note: * p-value <0.1; ** p-value <0.05; *** p-value <0.01		

Source: Authors' own research.

Results and discussions

Research findings

The results of the analysis showed that there was no significant difference between the three VR scenarios, meaning that the subjects felt the same sense of immersion when using the VR device and being isolated from the outside world, even though the purpose of the scenario was different, so for the users, as long as the content of the VR scenario was sufficient, they could concentrate on it.

The antecedents of immersion will be divided into two parts to explore. According to the results of the analysis of hypotheses H1 and H2 of this study, this study found that interaction and vividness do not have a positive and significant relationship effect on immersion. It shows that when users are exposed to new technology applications such as VR, the interaction with objects in the virtual reality environment and the vividness of the objects themselves do not necessarily enhance the sense of focus in the virtual reality scenario, although interactivity and vividness have been identified as two important characteristics of VR media (Cheng, 2014), since every human action may involve interactivity, their concepts, and definitions vary from study to study and should not be viewed at a single level. It is hypothesized that even if the user is not allowed to manipulate the device or the object is not designed realistically enough, as long as the user can intuitively recognize the surroundings and the object and can focus on the virtual scene, the target benefit can be achieved. The findings for H1 were somewhat different as compared to earlier research by Hudson et al. (2019). According to the findings of Hudson et al. (2019), the interaction had a significant impact on immersion. However, the findings of H2 can be somewhat compared to Kim et al.'s (2021) VR study, which found vividness to be in a significant relationship with perceived usefulness and enjoyment in an IKEA store setting.

As for the analysis of embodiment and media novelty, this study found that embodiment and media novelty have a positive and significant effect on immersion based on hypotheses H3 and H4, indicating that users' feelings of immersion and novelty of VR technology further increase their sense of focus on VR scenes when they are exposed to new technology devices such as VR. In the future, new output devices can be considered when planning to use VR as a marketing tool. This type of output device can enhance the overall sense of embodiment and technological media novelty of the VR scene. The results for H3 are similar to an earlier study by Leveau and Camus (2023), which also indicated a significant impact between embodiment and immersion. Furthermore, the results of H4 were somewhat similar to an earlier study conducted by Huang and Zhao (2022), which indicated a significant association between perceived novelty and immersion.

According to the results of the analysis of hypotheses H5 and H6, this study found that immersion has a positive and significant effect on perceived usefulness and satisfaction, showing that users are more likely to receive the meaning of the virtual space when they focus deeply on the VR scenario and gain utilitarian benefits and satisfaction from it. Therefore, the industry or developers can enhance the immersion of VR scenes by adding visual content or planning the route of the scenes to increase the user's operating time, or designing the scenes according to the user's needs and purposes, for example, adding the surrounding traffic and accommodation information to the tourist-related VR scenes to enhance the user's intention to play in the field, by planning from the needs of specific groups of customers using VR devices to strengthen their recognition of the value of VR scenes. The findings for H5 can be compared to a study by Barrett et al. (2021), which used VR immersion

in the VR learning context. According to Barrett et al.'s (2021) findings, VR immersion was significantly associated with perceived usefulness. Furthermore, the findings of H6 can be compared to a study by Hudson et al. (2019). The findings of Hudson et al. (2019) revealed a significant relationship between immersion and satisfaction.

The results of the analysis of Hypotheses H7 and H8 found that perceived usefulness had a positive and significant relationship effect on satisfaction and continuation intention, while the results of the analysis of hypothesis H9 found that satisfaction had a positive and significant relationship effect on continuance intention. The results were similar to a study conducted by Zhao and Khan (2021). The study by Zhao and Khan (2021) was related to online learning platforms and found significant relationships of perceived usefulness with satisfaction and continuous intention. In addition, Zhao and Khan's (2021) findings also revealed a significant association between satisfaction and continuous intention.

Implications of the study

Theoretical implications of this study expand our comprehension of the intricate dynamics governing Virtual Reality (VR) immersion (Cheng et al., 2023). By elucidating the pivotal determinants and their repercussions, the research enriches existing theoretical frameworks, refining models aimed at elucidating user engagement in virtual environments. The identification of these determinants not only deepens our conceptual understanding of immersion, but also lays the groundwork for future theoretical advancements within the broader realm of human-computer interaction (Okoro et al., 2023; Paes et al., 2023). Moreover, this research contributes to the discourse surrounding the amalgamation of psychological and technological perspectives, fostering a more comprehensive understanding of the factors shaping the immersive experience in VR (Liu et al., 2022).

On a practical level, the findings of this study have significant relevance for designers, developers, and practitioners in the VR industry. Insights into the determinants of immersion guide the refinement of VR content, enabling the creation of more compelling and effective virtual experiences. Understanding the consequences of immersion informs decision-making in diverse fields, from education and healthcare to entertainment and training. Practitioners can leverage this knowledge to optimize the design of VR applications, tailoring immersive environments to specific goals and user needs. Ultimately, the practical implications underscore the potential for harnessing VR technology in a manner that aligns with human cognitive and emotional processes, unlocking new possibilities for impactful and meaningful user experiences.

Research limitations and future research directions

In this study, although we tried to be rigorous in the experimental procedure, there were still human and material resources, as well as time constraints. First, since the sample structure is composed of college students, we can recruit different age groups in future VR scenario-related studies to create a more extensive and diverse sample structure for analysis. At the same time, in addition to virtual reality, augmented reality and hybrid reality combining the two, and even other innovative technologies, can be used as case studies.

Secondly, in terms of interaction and vividness, future research can focus on these two dimensions to explore the relevant literature in order to enhance its explanatory power and conduct further research for confirmation. The interaction involves multiple processes, functionalities, and other perspectives, and given the small number of operational

components of VR scenarios provided in this study, it is expected to be revised in future studies.

Finally, since the process of the experimental phase of this study is more complicated compared with other VR scene experiences, the experimental process can be simplified in the future, or the processing time can be divided into different time periods with longer breaks in order not to make the subjects feel tired and affect the effectiveness of filling out the questionnaire.

By collecting data and analyzing empirical evidence, this study can better understand the immersion of users when experiencing virtual reality scenes and the impact of causes and consequences, and help the industry establish value propositions from users' viewpoints and explore core customer segments. We hope to bring help to industry, academic researchers, and developers related to virtual reality to build a more competitive virtual reality platform.

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APPENDIX

Research Instrument

Construct	Item Codes	Items	References
Interaction	INT1	I had some control over the content of the VR device that I wanted to see.	Hongsuchon et al. (2023) and Gao & Boehm-Davis (2023)
	INT2	When I use a VR device there is quite a rapid between my actions and the response of the virtual environment.	
	INT3	The VR device could respond to my needs efficiently.	
	INT4	When I used a VR device, the applications I played usually load quickly.	
Vividness	VI1	When I was in the VR situation, I felt the virtual environment around me was clear.	Zhao & Khan (2021), Kim et al. (2021)

Construct	Item Codes	Items	References
	VI2	When I was in the VR situation, I felt the virtual environment around me was detailed.	
	VI3	When I was in the VR situation, I felt the virtual environment around me was vivid.	
	VI4	When I was in the VR situation, I felt the virtual environment around me was well-defined.	
Embodiment	ENB1	VR situation conveys the feeling of having another body.	Peck & Gonzalez-Franco (2021) and Stinglhamber et al. (2015)
	ENB2	VR situation convey the feeling of being another person.	
Media Novelty	MN1	Overall, I thought that being in a VR situation was novel.	Tokunaga (2013) and Yim (2011)
	MN2	Overall, I thought that being in a VR situation is unique.	
	MN3	Overall, I thought that using the VR device is more different than using traditional 2D technological products.	
	MN4	Overall, I thought that being in a VR situation was unusual.	
Immersion	IM1	At the time the experience in the virtual environment was my only concern.	Hamari et al.'s (2016) and Lee et al.'s (2013)
	IM2	I lost track of time while using a VR device.	
	IM3	I felt detached from the outside world.	
	IM4	I became very involved in the virtual environment forgetting about other things.	
Perceived Usefulness	PU1	I thought VR device was easy to use.	Xu et al.'s (2021) and Al-Adwan et al.'s (2023)
	PU2	I found the various functions in the VR device were well integrated, so I can use it more effectively.	

Construct	Item Codes	Items	References
	PU3	I would imagine that most people would learn to use the VR device very quickly.	
	PU4	I felt very confident using the VR device.	
Satisfaction	SAT1	My overall experience of VR device use was enjoyable.	Zhao & Khan's (2021) and Al Amin et al.'s (2023)
	SAT2	My overall experience of VR device use was pleasing.	
	SAT3	Using the VR device stimulates my curiosity.	
	SAT4	My overall experience of VR device use was very satisfactory.	
	SAT5	My overall experience of VR device use was a good idea.	
Continuance Intention	CI1	I would like to buy a VR device after this experience.	Guo et al.'s (2023), Rahardja et al.'s (2023), and Zhao & Khan's (2021)
	CI2	I would like to use the VR device frequently.	
	CI3	I would recommend the VR device to other people.	
	CI4	I would share my experience of using the VR device to other people.	

Source: Authors' own research.