

The Applications of Interface Design and User Experience in Virtual Reality

Hanqing Xie*

Monash University, Melbourne, Australia

*Corresponding author. Email: hxie0015@student.monash.edu

Abstract. With the rapid development of science and technology, the application of Virtual Reality (VR) technology is becoming more and more widespread. With its immersion, interactivity and expandability, VR technology has become a promising technology with broad application prospects. Therefore, this paper aims to investigate the factors that influence user experience in the design of user interface in VR environment, and to summarize the key points of VR user interface design in different application areas. The article will take interface design and user experience as the starting point to compare different user interface modes and their impact on user experience in VR environment; meanwhile, the design points of VR user interface in education field and game field and the impact factors on user experience in different scenarios are compared and summarized respectively. The final part of the article summarizes the user interface in VR environment in education and game field, and provides an outlook on the future improvement and enhancement of user experience in VR scenario.

Keywords: Virtual Reality, User Interface design, User Experience, VR Education, VR Game.

1. Introduction

Virtual Reality (VR), a virtual three-dimensional environment, is a new form of human-computer interaction created with the help of computer systems and various sensor technology generations [1]. Its main feature is to bring an immersive, real-world-like experience to users by mobilizing the human multisensory channel using existing high-tech hardware. With the development of VR technology applications, the competition in the VR has become more and more intense. Consumer expectations for VR products and the user experience they bring are getting higher and higher.

Obviously, "User experience" is a hot topic in the design of VR applications in recent years. In the VR scenario, the user experience is closely related to the important attributes of VR, which are immersion, interactivity, simulation, imagination, and a sense of autonomy, ownership and presence [2]. When users want to be fully immersed in the virtual environment, it is necessary to explore how to use effective interaction methods and appropriate design elements to better express the attributes of VR, thus enhancing the user experience and truly achieving the design goal of meeting the psychological needs of users [3]. In addition, the interaction of VR is gradually integrated with the somatosensory operation, which challenges the traditional User Interface design that mainly relies on specific visual elements such as screens, menus and buttons for interaction [4]. At the beginning of VR development, traditional interface elements were even considered to have a serious impact on the immersive user experience, as the experience mode of VR itself makes people feel like they are truly immersed in the virtual environment, and the abrupt appearance of buttons and menus can potentially pull users out of their immersion and induce a Blocking of Thought [5]. What's more, as VR development progresses, the content gradually evolves from simple roaming and display to the need for more immediate interaction, and the need for more information to be conveyed is raised, which means that the interface design in the VR environment meets the challenge and also ushers in the opportunity.

Furthermore, with such momentum, VR technology has been boldly tried to be applied in various fields of productive life, such as education, games, etc. Each field uses the characteristics of VR to break the inherent forms and create new ways. However, the academic summary information about User Interface design and user experience in the VR field is not comprehensive enough, hence, this

paper will analyse the User Interface design mode and its influence on user experience in the VR environment, and will summarize and conclude the main points of current User Interface design and factors affecting user experience in VR education field and VR game field respectively.

2. User Interface design modes and user experience in VR environment

The design elements in VR applications are divided into "user," "environment," "interface," and "interaction," of which the "interface" is the focus of the VR user experience [6]. The "human-computer interface" is the most common virtual interface in VR systems, which includes a series of functional navigation bars, dialog windows, message boxes and other graphical pages, as well as a three-dimensional spatial interface built using 3D modelling software, and the user's operation process is also completed by these interactive interfaces [5]. Therefore, VR interface design modes are an essential part of the user experience process.

2.1. User Interface Design Modes

The user has active visual control and spatial movement in the VR interface, which makes the user a part of the interface. Therefore, the mode of interface design greatly affects the user's experience in VR scenarios, and it is through the construction and design of these interactive interfaces that the information between the user subject and the computer network platform is formed, thus ensuring the accurate dissemination of perceptual data information in the VR environment. Nowadays, the modes of user interface design are mainly divided into scenario-based interface design, global interface design, and handheld interface design [7].

Scenario-based interface design: Scenario-based interface design mode is to integrate the interface and operation information into the virtual space and scene, which is the interface of direct contact between human and virtual space [8]. Therefore, in the VR scenario, the scenario-based interface design mode can restore the real-world scenes most intuitively, allowing users to enter the virtual space scenario and use their real-world experience to quickly learn and adapt to the operation process and make "interactive" interactions with the environmental objects in the virtual space. When users can bring all the visual and operational habits of the real world into the VR scenario experience, it greatly deepens the immersion of users in the interactive process and enhances the user experience (Figure 1-2).



Figure 1 The VR sculpting application "medium" using scenario-based interface design mode



Figure 2 The VR game "Waltz of the Wizard" using scenario-based interface design mode

Global Interface Design: The Systematic interface design mode, also known as the Global interface design mode, is an interface design from the user's perspective (Figure 3). In this mode, the user interface appears in a hovering manner, raising the basic functional interface, location descriptions, interaction instructions, etc. to the user [8]. The global interface is usually superimposed on other displays of the virtual space scene, so it is closer to the user's eyes, which can cause visual fatigue and virtual dizziness to some extent [8]. Therefore, the control interface and functional service pages of the system in this mode are mainly located at the first and second levels of the global interface, and usually use simple visual elements, such as wireframes, translucent software interaction pages, etc., to develop a variety of user interaction scenarios, adjust the size of the interface elements, interaction flow and jump links, so that the layout of the whole page conforms to the user's interaction behavior. However, in the process of design application, the global interface design mode interferes with the user's immersion in the experience process, and the depth of its design position also affects the user's visual experience, and without reasonable control, it will still cause a sense of oppression to the user's experience [9].

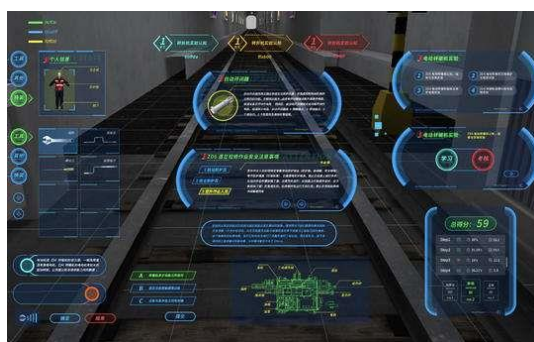


Figure 3 Global interface design mode

Handheld interface design: Handheld interface design mode is an interface mode that follows the user's hands in gestures (Figure 4-5). This mode is consistent with the user's daily life in handheld interaction, so it only requires the user to simply lift his or her arm to operate [10]. In this way, it effectively avoids complicated operations by users and does not cause visual fatigue. Moreover, due to the long-term human hand movement cooperation, this interface mode is very much in line with user experience and daily experience, easily and easily recognized and familiarized by users, easily completing the interactive operation, and making users get a comfortable user experience [8].



Figure 4 Handheld interface design from leap motion

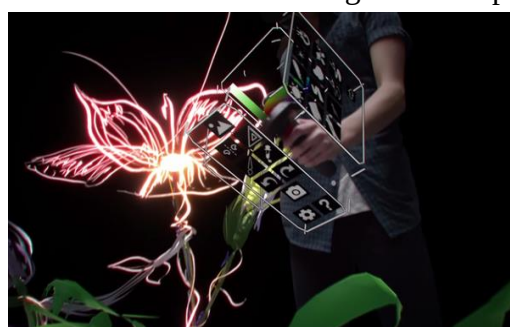


Figure 5 The VR drawing software "Tilt Brush" using handheld interface design mode

2.2. Natural User Interface

A natural user interface is a type of interface that represents a human-centered interface design goal that encourages users to interact with the computer in a natural, human-natured way [11]. Therefore, the ultimate goal of a natural user interface is to make the experience equally enjoyable for novice and expert users. Thus, a natural user interface is not a natural user interface, but rather an interface that feels natural to the user [12]. A natural user interface is a user interface that matches the existing experience or thought model of the target user group in the intended usage context. Based on the fact that the most essential characteristics of VR are immersive and interactivity, whether the interface design in VR environment conforms to the natural user interface and its impact on the user experience can be judged from the following aspects (Figure 6) [11].

Spatial realism: whether the VR environment is perceived as real by the user.

Safety and comfort: whether the user's physical and emotional state in the VR environment is good;

Motivation: whether the user's motivation to participate in the environment is strong;

Interaction Efficiency: refers to the level of interaction operation. Interaction efficiency affects the learning speed of novices, the user's mastery of the operation and concentration [11].

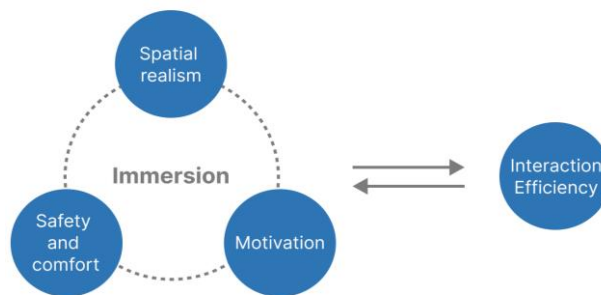


Figure 6 Natural user interface measurement dimension decomposition

2.3. Relationship between interface and user

Users can move around in a certain virtual space in the immersive environment, so the application of different interface design modes will generate different positional relationships with users, and the changes of these relationships will directly determine the user's recognition and operation, thus affecting the user's sense of experience [5]. Therefore, it also requires designers to make reasonable interface configuration at the beginning in order to better help users to complete the interaction under the natural user interface. Among these relationships, they can be mainly classified as Bound, Concomitant, Stationary and Free-form [13].

Bound: A bound interface also means that the interface is bound to a part of the user's virtual model, and its spatial location tends to change according to the user's actions [13]. The advantage is that the presentation is natural and easy to read, and the user can easily perceive and remember where the bound interface is located, e.g.: handheld interface design mode.

Concomitant: The characteristic of concomitant interface is that the interface often remains relatively stationary with the user's location in any space, i.e. wherever the user goes, the concomitant interface also follows, and the concomitant interface often presents a similar state to the user's eyes [13]. Accompanying interface is suitable for presenting information that is highly relevant to user's behaviour and has high stability, which may appear in systemic interface design and handheld interface design.

Stationary: Stationary interfaces can often appear as a specific part of the VR scene, they do not adjust or change their spatial position according to the user's posture and position information, instead they are always aligned with the model structure of the scene [13]. The advantage of a stationary interface is that it does not require any special state of the user, and the reading process is more relaxed.

Free-form: The free form interface is characterized by the user's ability to place and adjust the relative position of the interface in space at will, giving the user more room for personalization while also making the operation process complex and increasing the probability of error [13]. The advantage of the free-form interface is that it makes great use of the non-realistic nature of the virtual environment to manipulate the graphical interface with a high degree of freedom, allowing users to customize the relationship between the interface and their own spatial position on a large scale, so that the position of the interface can be freely changed according to their own task requirements and usage habits change, in the mode of systemic interface design, it may be possible to achieve such relationship settings [7].

The user interface model determines the relationship between the user and the interface, and these factors also influence the user experience (See Table 1).

Table 1. The relationship between user and interface in the user interface mode and the impact on user experience

VR interface design mode	Operation interface	User Experience	The relationship between the interface and the user
Scenario-based interface design	Interface and operation process into virtual scenarios	Consistent with real-world operating habits, greatly enhancing the immersion and user experience during the experience	Stationary
Global Interface Design	The interface appears in the scene as a hover	Users need to operate independently in the virtual world, and if the interface is not set properly, it is easy to try visual fatigue and dizziness, causing oppression to the user's experience	Stationary, Concomitant, Free-form
Handheld interface design	Interface follows the user's hands	Consistent with real-world handheld interaction, simple to operate and easy for users to complete the interaction, contributing to the user experience	Bound, Concomitant

3. User interface design and user experience based on VR education field

The new generation of information technology, represented by big data, cloud computing and VR technology, has been widely explored and applied in the education field. As mentioned above, VR technology has the characteristics of "immersion" and "interactivity", and these characteristics bring new opportunities for the development of the education industry [14]. As a result, the application of VR technology in the education industry today has a number of outstanding features, and various educational application scenarios continue to accelerate the landing. Among them, in the teaching and learning experience, VR technology application plays a positive role in the student-centered teaching scene.

3.1. Teaching Experience in VR Environment

VR teaching and learning experiences can be interpreted as different concepts of immersion, including: sensory immersion, challenge immersion, and imaginative immersion. Sensory immersion occurs when the learner interacts with the VR system, challenge immersion occurs "when one reaches a satisfactory balance of challenge and ability," and imaginative immersion occurs when the learner "uses his or her imagination to resonate with the task, or simply enjoys the VR system's fantasy". The intersection of the three immersion senses provides a fully immersive VR experience for the learner [15]. Sensory immersion is the connection between the learner and the interactive interface, while

challenge and imagination immersion are the connections between the learner and the VR system [14].

During the learning experience, VR learning scenarios provide learners with a better learning experience and enjoy learning through VR scenarios. The feedback of good experience is the result of multiple factors, which can be explored mainly from three factors: learners' motivation, concentration and engagement [16].

Motivation: In terms of motivation, adding new technology to the learning environment can have a positive impact on learner motivation, but more importantly, VR is not only a novel way to teach but also a powerful sensory experience that is different from traditional teaching methods, it can also attract students to actively explore and participate, stimulating their interest and curiosity in learning [16]. This kind of attraction is what is desperately needed in subjects that are generally considered boring, such as history teaching where VR recreates historical places or scenes to give students a strong sense of presence and immediacy, and further increases their interest and motivation in the subject [17].

Concentration: Teaching is a kind of information transmission, therefore, in terms of concentration, it is necessary to rely on concentration to maintain the effectiveness of information transmission [16]. High concentration will undoubtedly have a positive impact on learning efficiency, and attention has the characteristic of selectivity, i.e., the tendency to selectively process certain stimuli and ignore others, requiring that its mental activity be selectively directed to the object in question [18]. The immersive experience brought about by VR technology temporarily separates students from the real world, in line with the selective character, by avoiding a large number of distracting elements of the real world, thus enhancing the learners' attention to the presented content (Table 2).

Table 2. Key points of user interface design in VR teaching scene application

Information Display	The design of key information should be obvious: relevant information should be displayed, and the key information should be prominent. Irrelevant information should be excluded [16]. Enough information should be provided to the learner so that he or she can judge his or her status and make appropriate decisions.
Menu Setting	If there are menus in the interface, they should be intuitive and clear, and seen as a natural part of the VR system [20].
Geographical Location	If there is a mini-map in the interface, learners should be able to know where they are on the map, and learners should not be asked to memorize the design of the scenes [17].
Operation Process Display	The process display for beginners should be very clear and allow for quick and positive feedback [16].
Progress Access	Learners should be able to save progress in different states and can easily turn the system off and on [15].
Input Method	The input methods should be designed to be easily managed and have appropriate sensitivity and response. The input method should allow customization of the associated mapping [15].
View Layout	The visual presentation should give the learner a clear, at-a-glance view of where they are and the visual information bound to that location [19].
Customization	The interface should be designed in a way that allows the learner to customize aspects of the user interface to some degree [16].

Engagement: Better engagement comes from the immersive interactivity of VR, and interactivity plays an important role in enhancing the user experience [16]. As mentioned above, compared to traditional interactive multimedia, VR interaction is completely different, as the 3D model in the virtual environment interacts with the user in a way that is more in line with people's everyday behavioral perceptions, and this form of interaction combined with the interface that disappears into the environment brings an immersive multisensory interaction mode that greatly enhances the user experience for the learner [19]. This interaction design also makes learning an active process, as learners no longer passively wait for the teacher to teach them, but actively interact with the learning

content, which also means that the addition of VR technology has shifted the traditional teacher-based learning model to a learner-based model.

3.2. User Interface Design in VR Education Scenarios

The concept of immersion in the teaching scene cannot be separated from the interaction between users and the VR teaching scene. The user interface is the user interaction interface of the VR teaching scene, which plays a crucial role in the quality of teaching and learning. In the teaching process, the design of the user interface has a significant impact on whether the learners can acquire the target knowledge effectively and directly, and also plays a direct role in the motivation, concentration and participation of the learners as mentioned above. Due to the specificity and purpose of the instructional scenario, the user interface design is adapted to the information needs to be conveyed in the scenario, focusing on the following design elements: information display, menu settings, geolocation, operations, progress access, input, view, and customizability. These interface design elements are required to meet the behavior, mindset, and specific needs of the learners in the teaching and learning process in order to achieve the standards of a natural user interface that will positively contribute to the teaching and learning experience [16].

4. The application of interface design based on VR game field

Looking back at the history of information communication, technological development has driven the change of information communication media, and the emergence of VR has brought many new possibilities for game design. At the same time, the broad prospect of VR technology in the game field pushes interface designers to follow the trend and evolve, trying to transfer their skills from the limited, flat screen to the exploration and practice of a borderless three-dimensional world.

4.1. The Challenges of Interface Design in VR Game

At present, VR technology still has certain defects in the visual experience, designers need to design VR game interface design in line with the laws of human visual cognition, in order to create a better immersive experience for users, so as to stimulate the mind flow effect and achieve a better interactive experience [21]. The following will explain the dilemma of interface design in the VR game environment.

Interaction method change: In recent years, voice recognition and feedback of intelligent devices into thousands of households; thus, it can be seen that the future interface may exist in all visual and auditory, no longer rely on cumbersome input and display devices, "screen" everywhere, "buttons and menus" is very likely to weaken or even disappear [22].

Visual fatigue issues: The virtual environment of VR is a display method born from the intersection of flat images and real-world display methods, which is against the innate characteristics of human visual physiology, so there are still insurmountable defects in the comfort of the user experience, users may experience varying degrees of dizziness, visual fatigue, and even eye swelling, nausea and other phenomena [22]. Motion sickness is a common phenomenon in the VR experience at this stage: when the user experiences virtual movement at an inappropriate frequency, the nerve center will appear a protective response to prevent the body from further receiving these unstable messages, when people will produce dizziness and discomfort. Therefore, overcoming motion sickness in the process of user games requires both improvements in hardware equipment, but also from the perspective of the game user interface design to think and improve [23].

Interaction perspective change: When entering the VR world, the user's viewpoint shifts from 2D to 3D. While the traditional on-screen game interface gives a two-dimensional and flat visual impression, the interaction in VR is three-dimensional [22]. Therefore, the common screen interface design is concerned with functionality and practicality, while the VR user interface design should obviously focus more on the interactive experience.

4.2. User Interface Design Points in VR Game

The theory of mind flow, first proposed by psychologist Mihaly Csikszentmihalyi, refers to the feeling of betting one's mental energy completely on a certain activity; when mind flow is generated, there is a high sense of excitement and fulfilment, and this state of pleasure is the best state that game designers expect to bring to players. Therefore, user interface designers need to understand the causes and manifestations of mind flow, and study the ways in which the interface can bring good experiences to players and prolong the life of the game. In VR games, the interface is the medium for transmitting information between human and computer. In order to better meet the challenges mentioned above and better improve the user's immersion, it can be explored from various aspects combined with the theory of mind flow.

Style: The style of interface will determine the first feeling of users entering the interface. Therefore, a simple and unified User Interface style can reduce the unfamiliarity of players when they participate in game interaction and avoid distracted thinking; an appropriate weaker User Interface can better set off the scene screen, and using flashing lights or sounds to prompt users to operate can replace some of the buttons; a shallower floating layer can also prevent users from losing their way when jumping between complex floating layers, and if information can be grouped by layers, it will also be more helpful to If the information is grouped by level, it will also help users to select and operate [22].

Dynamic effect: Good use of dynamic effect design in the user interface can make the page originally in a static state show subtle, interesting changes, attracting the user's attention while giving life to the interface object. Due to their high frequency of use, the common functions in the game should reduce animation effects as much as possible and show information in a fast and direct way; the dynamic effect of switching between floating layers should be fast and natural, avoiding obvious interruptions [23]. Only by not detaching from the main scene of the game to the greatest extent can users be better "immersed" in the game and ensure the smooth realization of "mind flow".

Feedback: Providing correct and rapid feedback in the user interface can greatly enhance the user experience, and providing immediate feedback is one of the key principles of mind-flow theory [21]. Therefore, designers should develop the player's mind-flow experience in the design process based on the following principles: set clear goals, provide immediate feedback, maximize efficiency, and allow for discovery. Providing immediate feedback can help users understand whether their actions are completed and the results they produce in a timely manner, a principle that is critical to the impact of game interfaces. Therefore, good and timely feedback to the user should be correct, clear, fast and in the right place.

Auditory elements: VR provides a full range of information, and the interface design should take full advantage of these advantages to guide user interaction. In addition, adding sound and special effect feedback to the button sliding or pressing state will also reduce the user's confusion [23].

Physical comfort of the player: The design of game scenes should create a comfortable environment for users, avoiding scenes that are too bright or narrow leading to user eye fatigue. Designers need to understand the interaction rules between people and the environment in reality, and understand the adverse reactions that people will have in some specific virtual environments, such as fear of heights, claustrophobia triggered in small spaces, etc., to avoid designing scenes that cause users' discomfort [22]. Therefore, for motion sickness, the interface can be improved by modifying some elements in the scene.

Reading Flow: Text reading is one of the interface interaction methods, and text information in VR games is an important factor in providing clues and driving the plot. Because these texts are in a three-dimensional environment, readability is affected by distance, font, and font size [22]. At the same time, human short-term memory is limited and extremely unstable, too much reading and thinking will affect the continuity of the VR experience, the design interface to consider the limits of the human brain processing information, so a reasonably designed reading process in the game process is critical [23]. According to the mind flow theory, designers can increase the interest of reading by giving users a sense of control. For example, when the game needs to display a large

amount of text information, designer can try to cut the information hierarchy according to the degree of priority, which results in the need for the user to perform the operation of expanding and turning pages. The design of page-turning action needs to consider ergonomic principles, and a design that conforms to the natural movement of human fingers can make the user's reading experience closer to the real one, while also enhancing the user's sense of control in the game and ultimately gaining confidence and fun satisfaction.

5. Conclusion

In conclusion, by exploring the design points of user interface and the factors affecting user experience, the user interface in VR environment needs to be combined with the special needs of different fields in order to further design a more user-friendly interface and thus improve user experience. For the application of multiple user interface modes, the combination of different user interface modes is determined by the uniqueness of different scenes, thus building an interface mode that better meets the requirements of natural interface design and satisfies the needs of users. As for VR educational products, it is obvious that the design of user interface needs to pay more attention to teaching orientation and teaching focus in special educational purposes, highlighting the main purpose of interactive operation, and thereby improving the efficiency and user experience between teachers and students. Furthermore, in the field of VR games, the design of the user interface should consider the attributes of the game and the user's mind-flow feeling, and aim to help players enter the mind-flow state faster according to different game categories and attributes and operation methods. In the future, the application scope of VR will become more and more extensive, and the user interface will be built more realistically and harmoniously, more in line with the application characteristics of different fields, while at the same time, the user experience will be improved through the continuous improvement of technology and design to better meet the expectations of users.

References

- [1] I. Wohlgenannt, A. Simons, S. Stieglitz, Virtual reality. *Business & Information Systems Engineering*, 62(5), 2020, pp.455–461. DOI: <https://doi.org/10.1007/s12599-020-00658-9>
- [2] R. Francisco, N. Paulo, D. Emília. Using Virtual Reality to Assess User Experience. *Human Factors*, 54(6), 2012, pp. 964–982. DOI: <https://doi.org/10.1177/0018720812465006>
- [3] E.L.C. Law, V. Roto., M. Hassenzahl, A.P. Vermeeren, 2009, April. Understanding, scoping and defining user experience: a survey approach. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pp. 719-728. DOI: <https://doi.org/10.1145/1518701.1518813>
- [4] A. Bueckle, K. Buehling, P.C. Shih, and K. Börner, 3D virtual reality vs. 2D desktop registration user interface comparison. *PloS one*, 2021. 16(10), p.e0258103. DOI: <https://doi.org/10.1371/journal.pone.0258103>
- [5] K. Hind, L. Mohammed, A. Naveed. 3D user interface design and usability for immersive VR. *Applied Sciences*, vol. 9, no. 22, 2019, pp. 4861. DOI: <https://doi.org/10.3390/app9224861>
- [6] Fagernäs, Simon, et al. What Do Users Think about Virtual Reality Relaxation Applications? A Mixed Methods Study of Online User Reviews Using Natural Language Processing. *Internet Interventions*, vol. 24, 2021, p. 100370. DOI: <https://doi.org/10.1016/j.invent.2021.100370>
- [7] Y.M. Kim, I. Rhiu, 2020. A systematic review of a virtual reality system from the perspective of user experience. *International Journal of Human-Computer Interaction*, 36(10), pp.893-910. DOI: <https://doi.org/10.1080/10447318.2019.1699746>
- [8] P. Shi, Analysis of interface design patterns in the virtual reality context, Shanghai Arts and Crafts Vocational College, China Academic Journal Electronic Publishing House, 2018.
- [9] R Shi, N Zhu, HN Liang, S. Zhao Exploring Head-based Mode-Switching in Virtual Reality. In *2021 IEEE International Symposium on Mixed and Augmented Reality* 2021 Oct 4, pp. 118-127. DOI: <https://doi.org/10.1109/ISMAR52148.2021.00026>

- [10] Y. Wang, "An Experimental Investigation of Menu Selection for Immersive Virtual Environments: Fixed versus Handheld Menus." *Virtual Reality: The Journal of the Virtual Reality Society*, vol. 25, no. 2, 2020, pp. 409–419. DOI: <https://doi.org/10.1007/s10055-020-00464-4>
- [11] R. Daniele, C. Rizzi, and A. Vitali. "Virtual reality applications: guidelines to design natural user interface." In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, vol. 51739, p. V01BT02A029. American Society of Mechanical Engineers, 2018. DOI: <https://doi.org/10.1115/DETC2018-85867>
- [12] L.P. Fu, J. Landay, M. Nebeling, Y. Xu, and C. Zhao, Redefining natural user interface. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems* pp. 1-3. DOI: <https://doi.org/10.1145/3170427.3190649>
- [13] T. Zhu, Research on the application of human-computer interaction interface based on VR technology, Southeast University, 2019
- [14] Y. Slavova, M. Mu, A comparative study of the learning outcomes and experience of VR in education. In *2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 2018, March, pp. 685-686. IEEE. DOI: <https://doi.org/10.1109/VR.2018.8446486>
- [15] J. M.C. Glenberg, 2018. Immersive VR and education: Embodied design principles that include gesture and hand controls. *Frontiers in Robotics and AI*, 5, pp.81-90. DOI: <https://doi.org/10.3389/frobt.2018.00081>
- [16] X. Li, F. Zhao, S. Zhang, Research on the design and application of VR/AR teaching experience.
- [17] D. Kamińska, T.Sapiński, S.Wiak, T.Tikk, Haamer,. Virtual reality and its applications in education: Survey. *Information*, 10(10), p.318. DOI: <https://doi.org/10.3390/info10100318>
- [18] J. Parong, and R.E. Mayer, Learning science in immersive virtual reality. *Journal of Educational Psychology*, 110(6), p.785. DOI: <https://doi.org/10.1037/edu0000241>
- [19] G. Thoresteinsson, H. Denton, Ideation in a Virtual Reality Learning Environment: A pilot project from Iceland in Innovation Education. *International Research Conference* 2006.
- [20] A. Bowman, A. Chadwick A. Wingrave. "Design and evaluation of menu systems for immersive virtual environments." In *Proceedings IEEE Virtual Reality 2001*, pp. 149-156. IEEE, DOI: <https://doi.org/2001.10.1109/VR.2001.913781>
- [21] M.D. Cruea, Gaming the mind and minding the game: Mindfulness and flow in video games. In *Video games and well-being* (pp. 97-107). Palgrave Pivot, Cham. DOI: https://doi.org/10.1007/978-3-030-32770-5_7
- [22] A. Pagano, A. Palombini, Bozzelli. Arkaevision vr game: User experience research between real and virtual paestum. *Applied Sciences*, 10(9), p.3182. DOI: <https://doi.org/10.3390/app10093182>
- [23] C. Cruz-Neira, M. Fernández, Virtual reality and games. *Multimodal Technologies and Interaction*, 2(1), p.8. DOI: <https://doi.org/10.3390/mti2010008>