Literature Survey: The Potential of Integrating Immersive Experience and Aesthetic Experience in Virtual Reality Historical Event

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ARTICLE INFO	ABSTRACT
	This study intends to explore the potential of integrating of two major theories that stemmed from two entirely different disciplines, namely the human-computer interaction and the arts. Indeed, there are vast gaps when two different theories, such as technology and art, are to be unified to develop a new element that complements to both disciplines. Empirically, virtual reality as immersive technological innovations are progressively developed and evaluated among various disciplines. Virtual reality technically is customarily to immersive experience as a measurement tool while virtual three-dimensional animated environment in virtual reality is an aesthetic object that requires an aesthetic-friendly method as its measurement tool. The proposition of evaluation is to measure the user immersive experience and aesthetic experience when dealing with an art object that imbues with digital technology. Therefore, an integrative multidimensional evaluation is required to evaluate virtual reality environment. This study uses scientific literature survey which research papers are retrieved from Google Scholar, ScienceDirect, and Scopus. Thus, this paper reports on the potentials of integrating the immersive experience and aesthetic experience theories to evaluate a virtual reality historical event. It explains the concept of immersive experience and aesthetic experience in immersive virtual reality applications in general and museum digital preservation practices in particular. Then focuses on the concept idea of how to integrate immersive experience and aesthetic experience in virtual reality historical event application by discovering the construct and element from both theories. Thus, the finding unveils the possibilities of integration immersive experience and aesthetic experience in terms of integrating the construct and elements, contributing to contemplate new possibilities and discoveries in both fields and become catalysts for future research. This initial concept idea could become fundamental conceptual design reference of developing virtual reality system in museum context used by designers, developers and museum professionals. In the conclusion, this study concluded that there is a significant and lucrative potential to integrate both theory in developing immersive virtual reality systems. Hence recommend to a new integrative framework development that is applicable to immersive product development.

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1. Introduction

Digital preservation of cultural and historical heritage has been fostering by immersive technological media [1] hence advancing towards virtual museum strategy. Museum experience aims through museum exhibition is to give visitor many facts while exploring the museum collections. Visitors interact with history objects thus engage with its. This engagement could be seen as sense of immersion; however, it is semi immersion as user couldn't feel or explore the real situation. The evolution of immersive technology such as augmented reality (AR) [2], virtual reality (VR) [3-5], and extended reality (XR) [6] has change the visitors' perspective in viewing and appreciating history since never seen artifacts, buildings, historians and moments could come alive surround them. Virtual museum exploration [7] mediated by VR head mounted display [8] enabling individuals to virtually visit distant and inaccessible museums, historical sites [4,5], and art gallery [4]. Thus, VR technology has become one of the leading digital strategy in museum context [3] that provide immersion and engaging [11,12] experience for user to navigate [13] and explore the simulated [14] virtual historical environment. Absolutely, presents major contribution to digital preservation of local and global historical and cultural virtual heritage.

Powerful virtual reality system must first have a good sense of presence, interaction [15], immersion in order to enable users to obtain real experience, so as to achieve the purpose of system concept and context. The VR multi-sensorial affect, dynamic interaction and 3D virtual environment enhance visitors' psychological engagement with museum collection by transport the visitors to inaccessible places or to particular points of time and history, then being immersed in the storytelling. User should be connecting within through emotion. As a result, immersion, aesthetic and emotion elements' of historical storytelling in virtual museum applications engross VR researchers' interest. However, there still few studies are conducted for developing historical events using VR.

Meanwhile, most of the digital preservation efforts were mostly involved content of tangible cultural heritage such as artifact [12,16] instead of intangible especially on historical event chronology. VR projects in Malaysia also focus more on recreation of heritage site [17] and reconstruct architectural heritage building [18-19]. In fact, with immersive and interactive of VR features', more research on conveying historical event, moment, situation, or process could be explored [20] and evaluated from immersion and aesthetic dimension.

In another direction, the evolution of head-mounted display (HMD) and hand gesture technology consequently produces multitude VR museum [21] applications. VR studies attempt to design VR applications which practically accepted by specific or targeted user. However, due to multitude and multidimensional complexity of VR installations, the evaluation facing more challenge due to various level of user's perception and prior experience.

In practical sense, the ideal state of virtual reality experience is evaluated after the user psychological [22,23] and phenomenological [24–26] experienced the virtual world, gained both immersive and aesthetic experience [26–28], hence felt presence [18,19], appraisal [22] and appreciate [23] the world. In short, the experience is not adequately captured by the single dimension evaluation. Aligned with this, a multidimensional evaluation framework is required to measure the quality of VR applications. Therefore, emphasizing the need for an extended paradigm of evaluation and analysis framework by integrating two or more dimensions resulted from VR experience.

On top of that, this study reports survey on scientific literature on the potentials of integrating immersive experience and aesthetic experience theories to evaluate a VR historical events application by discovering the construct and element from both theories. Based on this purpose, a few questions arose that guide this exploration;

i.   What the concept of immersive experience and aesthetic experience in virtual museum?
ii. How to integrate immersive experience and aesthetic experience to evaluate VR historical event application?

Therefore, the survey conducted based on few objectives;

i.   To explains the concept of immersive experience, aesthetic experience, VR systems in general and historical event as object and narrative of museum collection.
ii. Describe the concept idea of integrating immersive experience and aesthetic experience in VR historical event application.

Most of the research papers are retrieved from Google Scholar, ScienceDirect, and Scopus. Certainly, result of this study; the components and elements of immersive experience and aesthetic experience described will contribute to the development of a new integrative model that is applicable to interactive immersive product development.

2. Immersive Experience

Immersive experience is the sense of presence [30] and sense of illusion [31] experiences through five human sensory. While immersive experience in VR defined as user experiences the sense of presence [32], sense of place and sense of immersion within oneself and virtual environment in the VR system.

VR falls under realm of Human Computer Interaction (HCI). Therefore the development of VR system uses the user experience approach [33] as a method of designing and evaluating the effectiveness of VR product [34]. Previous study shows, user experience design approach has identified immersive experience components [35] such as: immersion, presence, disorientation, sense of control, pleasantness, exploration and simulator sickness. Therefore, immersive experience always measured by main components which is presence and immersion. These two terms are used interchangeably depends on researchers' perspective.

A contemporary immersive VR aims to produce immersive experience, by allowing user to interact with objects and move in virtual space which provide high sense of presence in virtual environment. Dynamic interactivity [34] of multisensory input and option of embodiment could increase the effectiveness of immersive VR system developed. More study is conducted on designing realistic interactions between the virtual and the real. Admittedly, the interaction in VR is vital component influencing VR experience.

Virtual environment with high quality of 3D visual representation display projects within HMD technology provide users the sense of real. Degree of realism, accuracy, level of details, fidelity and relevancy of virtual environment [36,37] are main elements affecting user's immersion. Immersion in virtual environment have been studied in different types of environment and conditions.

Study of immersive experience affecting by visual information [38] in immersive VR could be expand to 3D animation aspects, including principles of animation to evoke the sense of appealing among viewer. Different style of 3D animation could be perceptual stimuli of how user perceived historical event in VR. Interactive 3D models and animation constructed as visual information in virtual environment are aesthetic objects. Thus, immersive experience in VR could also be measured through aesthetic perspective. Therefore, immersive experience could be evaluated technically and aesthetically in term of system and narrative for VR to be high immersive product of a good user experience.

3. Aesthetic Experience

Aesthetic experience theory is psychological character that widely investigated in many discipline and interdisciplinary study. In this digital era, aesthetic experience theory draws parallel connection between the development of aesthetic field and digital technology [39].

The aesthetic experience is the human mental response; perception [40] and sensation [41] generate feelings of certain emotion towards beauty and art of aesthetic objects. Earliest aesthetic experience study referred painting as aesthetic object and described from art style and art school perspective. It is essentially important to describe the elements that stimulate aesthetic experience and how those elements could be develop to optimized aesthetic experience in terms of attention, appreciation and appraisal [20,29] dimensions. Those dimensions are compiled as aesthetic emotions [43].

In VR, most computer generated images in virtual environment constructed using art elements such as shape, space, size, light, texture, and colour are aesthetic cues [42] that affect user cognition and perception while perceived 3D visualisation. User cognition and perception at post-phenomenology stage determine their level of aesthetic experience evaluated in various dimensions. While Elver Boz *et al.,* [28], suggested that human aesthetic experience measured three key dimensions, namely familiarity, excitement, and fascination. Somehow, user must perceive beauty and art with appropriate attitude to show appreciation [42]. Attitude affecting by user prior experience [22] within his real world experience will be shown through action or behaviour and feelings. It also reflects as human sense of taste that mostly about human perceptions and sensitivity towards aesthetic objects around them. Elements such as originality, realism and cultural significance [38] in virtual environment must be construct conceives of the originality characteristic of real world. Thus, how user perceived aesthetic experience somehow will affect their level of immersion [26,44] while using VR.

For narrated visual art media such as drama, theatre, animation and film, involve storytelling [45] approach, hence current modern art including VR needs comprehensive and constructive view of interpretation binds to aesthetic experience model [20,21]. VR is conceptualised as artistic medium [8] according to its user interaction within the virtual environment from aspects namely;

i. immersion
ii. navigation
iii. transformation
iv. agency that shows emotional expression

Establishing concept of aesthetic experience using basic liking scale or pleasure [46] and more complex using unusual emotions such anger, disgust, confusion, shame and embarrassment [47] towards an art could be the fundamental scale to measure user experience in VR. Aesthetic experience is studied from post-phenomenological perspective in virtual museums context [24] to identify how mediated technology functionality shapes the way in which art is experienced from cognitive, perception, attitudes, behaviour and presence dimension.

Furthermore, Hashim *et al.,* [48] has developed the Hexagon Aesthetic User Experience (AUX) model consists of aesthetic and user experience components and elements as Figure 1. Hence this study is trying to integrate the immersive experience and aesthetic experience theory for enhancing user experience while using VR technologies.
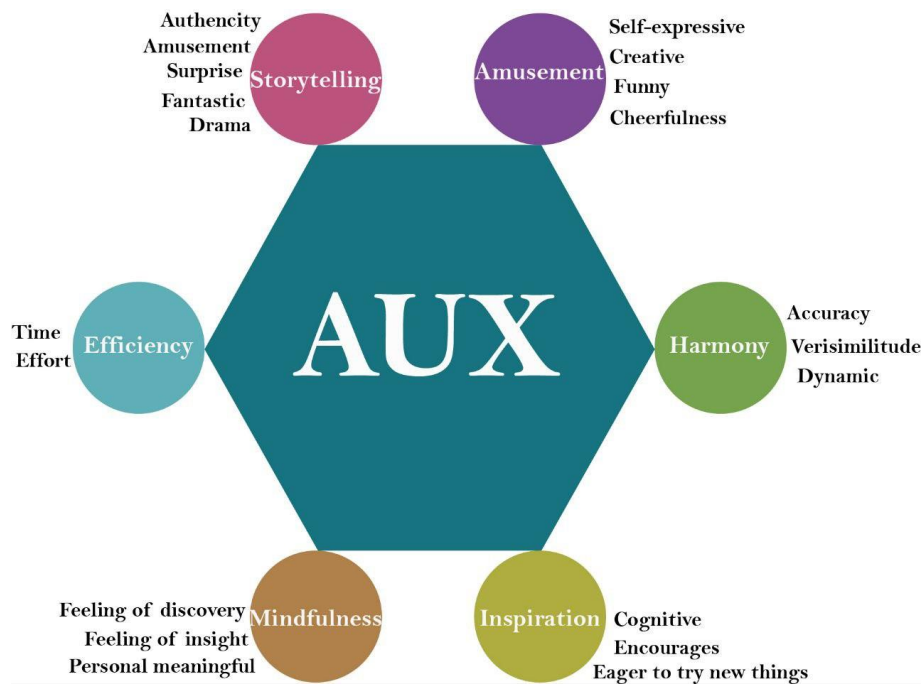
Fig. 1. The Hexagon AUX Model [48]

4. Historical Event

An historic event is a significant event such as war, covenant and etc. that stands out as having significant, history-changing impact. In the digital preservation context, historical event is categorised under intangible heritage.

Advance development of digitisation technology leads practices that have been done manually to be done digitally and which transformed the physical form of subject into digital form. Conventional history telling is usually through printed historical book, text-based literature on web, short animation or film. But today the delivery approach has changed into more interactive way [12] with support of ICT and digital technology. Through emerging of digitisation devices and techniques has particularly resolved hassles to preserve the desolate historical event.

VR remarkably providing new forms of historical and cultural heritage access [49]. Historical event conceived of factual and contextual dimension of information such as historical actor, event and process [50]. Those dimension explained detail the historical location or place, age or year, historical figure and storyline. Conveying a virtual historical event in VR requires three-dimensional visualisation [37] and composition process of all elements such as historian character and personality, setting or background related to era and cultural aspects, dialogue, sound, cinematographic aspects, semiotic elements and story length. That transmitted information's are history knowledge's which could be categorise under principal components of VR historical event such as site, building, object, narrative and age and time. In fact, become a new form of digital visual artworks or categorised as virtual heritage. The virtual historical event constructed of 3D models and animation thus are aesthetic objects.

Aylett's storytelling approach [51] could become a guideline for storification process and the role of the user and narrativisation [45] of historical event content narrated using VR. Narrative elements such as combination of mimetic and diegetic approach, character-based narrative form, particular camera angles and positions, establishment of believability for emotional contribution and language as cinematic system are essential for the content, technical and VR narrative.

Meanwhile, appreciation of historical event could be based on appraisal dimension. Appraisal Framework by Martin *et al.,* [50] lists attitude as the component of Appreciation system that lineages subsystem; affect, judgement and appreciation, in order to analysis events.

Thus, those aspects could be main components, constructs and elements to be explored and integrated as evaluation dimensions of VR historical event.

5. Virtual Reality (VR)

Development of immersive technology fields involve AR, VR, XR and metaverse. VR is different from other immersive media because of its immersive and dynamic interaction [52]. With used of non-HMD and HMD device [15], VR has been experimented in various aspect of technical to maximise sense of immersion. Earlier VR technology use in heritage preservation studies [18], using web based [53], Spherical High Dynamic Range Virtual Reality (HDRVR) technology uses image or photograph with a 360-degree view of the environment or atmospheric dome [19,54]. Those VR concept application are semi immersive VR adoption because it is not involves the VR headset or head mounted display google [55] supported with hand gesture devices technology. Around 2016, VR headsets devices are commercialised to public with affordable prices make it acceptable within various research disciplines. Immersive VR headset and handheld brings fully 360-degree atmospheric view, 3D space, 3D realistic manipulated objects, multisensory channel input and output giving high degree of interactivity [56] and causing fully embodiment.

VR give user the sense of being there, sense of reality, visually and auditorily sense properties of the real world, navigate around virtual space [57], explore process in real-time, presence, contextual information through narrative approach, sense of touch and interact with digital object like physical object. In addition, VR techniques underlay design elements such as, visual configuration, audio configuration, locomotion mode, duration [58], mode of interaction [27] and mode of feedback [59].

Besides that, VR applications created for the purposes of explaining, educating, and interpreting story or concept are dramatically differ from artworks such as painting in VR that become "alive" because it intensified aesthetic experience and enhances art appreciation [7,21] reflection of aesthetic emotions. Most recent studies on VR museum focused on measuring how VR interactivity could affect user cognition, produce perception thus evoke presence [60] and immersion [26] but in single dimension.

As VR storytelling [61] can adopt the theatre narrative approach, it is required to let user experience the cognitive shift then the emotion shift. User cognition processing aesthetic cues [42] from virtual historical content consists of virtual human or character and environment or setting. Other historical informations are age, year, native culture of the history and flow of the event. There are positive [46] and negative emotion [47] categorised under aesthetic emotion scale [43] for expressing feeling towards narrated content for historic context.

For enliven historic lesson or message, user need freely engaged with virtual artworks via an eye-tracking-enabled VR headset to visually and auditorily [62] undergone or immerse emotionally into historic moment. In other words, the VR represents the user control of the virtual world or authorship [63] which the ability to change the virtual environment properties like in real world. In a practical sense, the virtual and real body come together to create new sense of experience in which digital objects can be interacted and manipulated through user sensory adaptation using designed mode of interaction [27] and mode of feedback [59].

VR user experience from ergonomic perspective [29] is a visionary and sensory incorporated technology that embedded multimodal senses, mechanical processes, and input and output devices, feedback, real-time tracking of body gesture and contextual information. Selzer & Castro [58] have

listed VR immersion metrics which are visual configuration, audio configuration, locomotion mode and duration. Several VR features that have been verified through previous work are display, interaction, locomotion and feedback.

HMD devices is a VR headset with camera and motion tracking sensors. This stereoscopic view brings live surrounding around user evoke sense of immersion. Display involves technical aspect of VR system such as resolution, field-of-View (FOV), frame rate (FPS), stereopsis, antialiasing (MSAA), type of visualisation such as text-based or object-based, visual configuration such as textures, illumination, saturation, brightness, contrast, sharpness, shadows, reflections, 3D models detail, depth-of-field, particles and audio configuration such as sound field, spatial audio and reverb.

Various interaction techniques used for interactive 3D environment, listed from non-immersive and immersive interaction techniques such as navigation, selection & manipulation and system control and multisensory channel (vision, auditory, tactile, gesture). Locomotion options give various type of virtual movement; natural walking, walking-in-place, and teleportation. While various feedback mode ranges from multisensory channel such as eye-tracking, hand and body gesture recognition, haptic, recognition or real-time tracking or motion-tracking.

Visualisation in the virtual environment consists of images [64], 2D graphics, 3D models and video [65]. 3D models with high level of authenticity [37], fidelity [66], realism [67] gain more attention, engagement and sense of presence. Therefore, VR system is mainly characterised by an advanced virtual environmental development, as well as interactivity promote both of the user's engagement with the virtual objects and within the environments. Those are technical considerations which should be taken into account while developing and evaluating VR applications.

6. Integrating the IX and the AX in the VR Historical Event

VR as one of the immersive media that relates to the science of HCI. Being immersive within VR product is vital user experience, termed as immersive experience. In literature review, there are two primary components, that are immersion [56] and presence, which define immersive experience as to provide immersive user experience in VR.

It should be noted, emotional components play a role in stimulating immersive experience and aesthetic experience based products to understand the immersive experience and aesthetic experience constructs and elements in VR historical event. Positive emotion attributes of the user experience by means to promote a product are essential for evaluating the effectiveness and efficiency of a VR product whether it could provide a real experience; feeling of engagement [68] and satisfaction without virtual sickness or symptom. However, immersive experience in VR system, can effectively be measured according to positive and negative emotion attributes respective to immersion and presence aspect in term of VR narrative and visualisation. Based on this argumentation, this study will specify how emotional elements constitute a significant component of immersive experience toward VR narrative and visualisation, which is mainly designed to evoke the positive and negative emotion. There are several immersive experience elements commonly found in VR, namely; role, social interaction, enjoyment, engagement and satisfactory and etc.

Since narrative of virtual historical event is constructed from 3D visualisation information, classified as three-dimensional artworks or aesthetic object, thus the measurement method should be viewed from an aesthetic perception and judgments in two contexts: immersive bodily experience [69] and 3D interactive virtual setting [70]. The evaluations based on subjective measures of aesthetic experience such as ratings on liking, novelty, complexity, perceived viewing duration [70] and aesthetic appeal [43] subscales namely prototypical aesthetic emotions (e.g., the feeling of beauty,

being moved, fascination, and awe), epistemic emotions (e.g., interest and insight), and emotions indicative of amusement (humor and joy).

Therefore, this study purposes the potential of development an integrative model using factor analysis that can validate the integration of the two theories (i.e., the immersive experience and the aesthetic experience). This highlights the importance of integrating both the immersive experience and the aesthetic experience in the VR historical event because the VR is an HCI-based product and highly relevant to immersive experience as a means of measurement. Conversely, we found there are no element of the aesthetic experience in the VR historical event although arts are used as its subjects.

7. Conclusion

A literature review has been conducted about the immersive experience, aesthetic experience, VR systems in general and historical event as object and narrative of museum collection in digital preservation context. Immersive VR can offer great advantages for preserving history by providing user dynamic participatory interaction [45] within 3D animated virtual environment to experience historical moment.

Reviews show how most papers reported experiments the use of VR in museum context in terms of immersion and presence, perception, storytelling, interactive navigation approach, interaction mode, visualisation of virtual environment, feedback mode, HMD and etc. Most of the study based on immersive art gallery tour, historical site visit and architecture building heritage exploration. Thus, reveal that there is no VR of historical event storytelling with 3D animated virtual environment.

The development of immersive VR technology enables knowledge about HCI and immersive experience to explore new possibilities in the field of reality technology. Integration of VR technology not only involves immersive experience's potential but also celebrates other elements like aesthetic experience if it involves an aesthetic object, as emphasised on 3D animated virtual environment. With massive development of VR technology, aesthetic object can flourish further by using VR technology incorporating with aesthetic objects. Defining immersive experience and aesthetic experience elements could help us to conduct present research.

The conjunction of HCI via the immersive VR technology as its product and the immersive experience as its measurement tool, while the aesthetic object represents the 3D animated virtual historical environment as its product and the aesthetic experience as its measuring tool. Certainly, there are some exciting elements when the combination of these two theories is studied and tested in the VR historical event.

Besides that, the congruent combination of VR and virtual historical environment will become a new virtual heritage of museum digital collections other than existing intangible virtual heritage such as artefact, performing art, craft and destroyed building. This combination also presents an insight into variation of a new method in the VR application that embraces the reproduction of other simulated virtual environment.

Consequently, based on related literature study, this paper unveils the integration idea of immersive experience and aesthetic experience in order to contemplate new possibilities and discoveries in both fields and become catalysts for future research. On the basis of objective and discipline, the integration will formulate new inventions in a combination of art and technology. This initial concept idea could become early conceptual design reference of developing VR system in museum context used by designers, developers and museum professionals. Thus, the finding concluded that there is a significant and lucrative potential to integrate both theory in developing

immersive VR systems. Hence contribute to a new integrative model development that is applicable to interactive immersive product development.

Future work will be a development of suggested framework that illustrates the integration of immersive experience and aesthetic experience theory in immersive VR historical event. This involve mapping and evaluating phase; the selection of component and element through expert review and testing using Fuzzy Delphi Method in order to develop a new model. The model will be used as vital reference model in the development process of VR historical event application.

Acknowledgement

References

[1] Shein, Esther. "Preserving the past with immersive technologies." *Communications of the ACM* 65, no. 12 (2022): 15-17. https://doi.org/10.1145/3565978

[2] Nguyen, Vinh T., Kwanghee Jung, SeungChul Yoo, Seungman Kim, Sohyun Park, and Melissa Currie. "Civil War battlefield experience: Historical event simulation using augmented reality technology." In *2019 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR)*, pp. 294-2943. IEEE, 2019. https://doi.org/10.1109/AIVR46125.2019.00068

[3] Shehade, Maria, and Theopisti Stylianou-Lambert. "Virtual reality in museums: Exploring the experiences of museum professionals." *Applied sciences* 10, no. 11 (2020): 4031. https://doi.org/10.3390/app10114031

[4] Huang, Yu-Chun, and Sooyeon Rosie Han. "An immersive virtual reality museum via second life: extending art appreciation from 2D to 3D." In *HCI International 2014-Posters' Extended Abstracts: International Conference, HCI International 2014, Heraklion, Crete, Greece, June 22-27, 2014. Proceedings, Part I 16*, pp. 579-584. Springer International Publishing, 2014. https://doi.org/10.1007/978-3-319-07857-1_102

[5] Garzotto, Franca, Vito Matarazzo, Nicolò Messina, Mirko Gelsomini, and Carlo Riva. "Improving museum accessibility through storytelling in wearable immersive virtual reality." In *2018 3rd Digital Heritage International Congress (DigitalHERITAGE) held jointly with 2018 24th International Conference on Virtual Systems & Multimedia (VSMM 2018)*, pp. 1-8. IEEE, 2018. https://doi.org/10.1109/DigitalHeritage.2018.8810097

[6] Kontopanagou, Katerina, Athanasios Tsipis, and Vasileios Komianos. "A framework for exploring churches/monuments/museums of byzantine cultural influence exploiting immersive technologies in real-time networked environments." *Technologies* 9, no. 3 (2021): 57. https://doi.org/10.3390/technologies9030057

[7] Baradaran Rahimi, Farzan, Jeffrey E. Boyd, Jennifer R. Eiserman, Richard M. Levy, and Beaumie Kim. "Museum beyond physical walls: an exploration of virtual reality-enhanced experience in an exhibition-like space." *Virtual Reality* 26, no. 4 (2022): 1471-1488. https://doi.org/10.1007/s10055-022-00643-5

[8] Kim, Bo. "Virtual reality as an artistic medium: A study on creative projects using contemporary head-mounted displays." (2016).

[9] Kersten, Thomas P., Felix Tschirschwitz, and Simon Deggim. "Development of a virtual museum including a 4D presentation of building history in virtual reality." *The international archives of the photogrammetry, remote sensing and spatial information sciences* 42 (2017): 361-367. https://doi.org/10.5194/isprs-archives-XLII-2-W3-361-2017

[10] Deggim, Simon, Thomas Kersten, Felix Tschirschwitz, and Nils Hinrichsen. "Segeberg 1600-reconstructing a historic town for virtual reality visualisation as an immersive experience." In *5th International Workshop LowCost 3D–Sensors, Algorithms, Applications, 28–29 November 2017, Hamburg, Germany*, pp. 87-94. Copernicus, 2017. https://doi.org/10.5194/isprs-archives-XLII-2-W8-87-2017

[11] Chang, Hsin-Lu, Yung-Chi Shih, Kai Wang, Rua-Huan Tsaih, and Zhiyan Lin. "Using virtual reality for museum exhibitions: the effects of attention and engagement for National Palace Museum." (2018).

[12] Jonauskaite, Domicele, Nele Dael, Loïc Baboulaz, Laetitia Chèvre, Inez Cierny, Nicolas Ducimetière, Anna Fekete et al. "Interactive Digital Engagement With Visual Artworks and Cultural Artefacts Enhances User Aesthetic Experiences in the Laboratory and Museum." *International Journal of Human–Computer Interaction* (2022): 1-14. https://doi.org/10.1080/10447318.2022.2143767

[13] Marín-Morales, Javier, Juan Luis Higuera-Trujillo, Carla De-Juan-Ripoll, Carmen Llinares, Jaime Guixeres, Susana Iñarra, and Mariano Alcañiz. "Navigation comparison between a real and a virtual museum: time-dependent differences using a head mounted display." *Interacting with Computers* 31, no. 2 (2019): 208-220. https://doi.org/10.1093/iwc/iwz018

[14] Hajirasouli, Aso, Saeed Banihashemi, Anoma Kumarasuriyar, Saeed Talebi, and Amir Tabadkani. "Virtual reality-based digitisation for endangered heritage sites: Theoretical framework and application." *Journal of Cultural Heritage* 49 (2021): 140-151. https://doi.org/10.1016/j.culher.2021.02.005

[15] Lee, Jiwon, Mingyu Kim, and Jinmo Kim. "RoleVR: Multi-experience in immersive virtual reality between co-located HMD and non-HMD users." *Multimedia Tools and Applications* 79 (2020): 979-1005. https://doi.org/10.1007/s11042-019-08220-w

[16] Ishak, Siti Mastura Md. "Lawi Ayam: Aesthetic Experience And Design-User System Assesment Of A Malay Weapon Artefact." *Institute Of Graduate Studies University Of Malaya Kuala Lumpur* (2017).

[17] Aziz, Kamarulzaman Ab, and Tan Gek Siang. "Virtual Reality and Augmented Reality combination as a holistic application for heritage preservation in the Unesco World Heritage Site of Melaka." *International Journal of Social Science and Humanity* 4, no. 5 (2014): 333-338. https://doi.org/10.7763/IJSSH.2014.V4.374

[18] Sharif, Harlina Md, and Hazman Hazumi. "RECONSTRUCTION OF THE EARLIEST MOSQUE IN MALAYSIA USING VIRTUAL REALITY TECHNIQUE." *Archives & Museum Informatics* (2004): 2.

[19] bin Hashim, Khairul Hazrin, and Muhammad Jafni bin Jusof. "Spherical high dynamic range virtual reality for virtual tourism: Kellie's Castle, Malaysia." In *2010 16th International Conference on Virtual Systems and Multimedia*, pp. 297-300. IEEE, 2010. https://doi.org/10.1109/VSMM.2010.5665945

[20] Pickard, Zoë Faye. "Representing Difficult Histories in the museum: Virtual and Augmented Reality as Tools for Communicating Difficult and Dissonant Histories." PhD diss., University of Pittsburgh, 2022.

[21] Gockel, Bianca, Holger Graf, Alfonsina Pagano, Sofia Pescarin, and Joakim Eriksson. "VMUXE: an approach to user experience evaluation for virtual museums." In *Design, User Experience, and Usability. Design Philosophy, Methods, and Tools: Second International Conference, DUXU 2013, Held as Part of HCI International 2013, Las Vegas, NV, USA, July 21-26, 2013, Proceedings, Part I 2*, pp. 262-272. Springer Berlin Heidelberg, 2013. https://doi.org/10.1007/978-3-642-39229-0_29

[22] Marković, Slobodan. "Components of aesthetic experience: aesthetic fascination, aesthetic appraisal, and aesthetic emotion." *i-Perception* 3, no. 1 (2012): 1-17. https://doi.org/10.1068/i0450aap

[23] Leder, Helmut, Benno Belke, Andries Oeberst, and Dorothee Augustin. "A model of aesthetic appreciation and aesthetic judgments." *British journal of psychology* 95, no. 4 (2004): 489-508. https://doi.org/10.1348/0007126042369811

[24] Moens, Bart G. "Aesthetic experience in virtual museums: A postphenomenological perspective." *Studies in Digital Heritage* 2, no. 1 (2018): 68-79. https://doi.org/10.14434/sdh.v2i1.24468

[25] Vindenes, Joakim, and Barbara Wasson. "A postphenomenological framework for studying user experience of immersive virtual reality." *Frontiers in Virtual Reality* 2 (2021): 40. https://doi.org/10.3389/frvir.2021.656423

[26] Diodato, Roberto. "Virtual Reality and Aesthetic Experience." *Philosophies* 7, no. 2 (2022): 29. https://doi.org/10.3390/philosophies7020029

[27] Brinck, Ingar. "Empathy, engagement, entrainment: The interaction dynamics of aesthetic experience." *Cognitive processing* 19, no. 2 (2018): 201-213. https://doi.org/10.1007/s10339-017-0805-x

[28] Elver Boz, Tugce, Halime Demirkan, and Burcu A. Urgen. "Visual perception of the built environment in virtual reality: A systematic characterization of human aesthetic experience in spaces with curved boundaries." *Psychology of Aesthetics, Creativity, and the Arts* (2022). https://doi.org/10.1037/aca0000504

[29] Kim, Yong Min, Ilsun Rhiu, Minshik Rhie, Hye Seon Choi, and Myung Hwan Yun. "Current state of user experience evaluation in virtual reality: a systematic review from an ergonomic perspective." In *Proceedings of the human factors and ergonomics society annual meeting*, vol. 63, no. 1, pp. 1274-1275. Sage CA: Los Angeles, CA: Sage Publications, 2019. https://doi.org/10.1177/1071181319631080

[30] Heater, Carrie. "Being there: The subjective experience of presence." *Presence Teleoperators Virtual Environ.* 1, no. 2 (1992): 262-271. https://doi.org/10.1162/pres.1992.1.2.262

[31] Stevanov, Jasmina, Slobodan Marković, and Akiyoshi Kitaoka. "Aesthetic valence of visual illusions." *i-Perception* 3, no. 2 (2012): 112-140. https://doi.org/10.1068/i0455aap

[32] Steuer, Jonathan, Frank Biocca, and Mark R. Levy. "Defining virtual reality: Dimensions determining telepresence." *Communication in the age of virtual reality* 33 (1995): 37-39.

[33] Zarour, Mohammad, and Mubarak Alharbi. "User experience framework that combines aspects, dimensions, and measurement methods." *Cogent Engineering* 4, no. 1 (2017): 1421006. https://doi.org/10.1080/23311916.2017.1421006

[34] Rubio-Tamayo, Jose Luis, Manuel Gertrudix Barrio, and Francisco García García. "Immersive environments and virtual reality: Systematic review and advances in communication, interaction and simulation." *Multimodal Technologies and Interaction* 1, no. 4 (2017): 21. https://doi.org/10.3390/mti1040021

[35] Kauhanen, Otto, Heli Väätäjä, Markku Turunen, Tuuli Keskinen, Esa Sirkkunen, Turo Uskali, Vesa Lindqvist, Chelsea Kelling, and Jussi Karhu. "Assisting immersive virtual reality development with user experience design approach."

In *Proceedings of the 21st International Academic Mindtrek Conference*, pp. 127-136. 2017. https://doi.org/10.1145/3131085.3131126

[36] Budhram, D. R. "Exploring presence in virtual reality." Master's thesis, University of Twente, 2021.

[37] Huggett, Jeremy. "Virtually real or really virtual: Towards a heritage metaverse." *Studies in digital heritage* 4, no. 1 (2020): 1-15. https://doi.org/10.14434/sdh.v4i1.26218

[38] Champion, Erik. "History and cultural heritage in virtual environments." *The oxford handbook of virtuality* (2014): 269-283. https://doi.org/10.1093/oxfordhb/9780199826162.013.020

[39] Manera, Lorenzo. "Medial Environments, Virtual Images and Aesthetic Experience in the Digital Age." In *How Images Behave*, pp. 201-204. Hungarian Academy of Sciences, 2020.

[40] Gonzalez-Franco, Mar, and Jaron Lanier. "Model of illusions and virtual reality." *Frontiers in psychology* 8 (2017): 1125. https://doi.org/10.3389/fpsyg.2017.01125

[41] Ramírez, Mario Teodoro. "VIRTUAL SENSATION. SENSORY IMAGINATION AS FACULTY OF AESTHETIC EXPERIENCE." *INVESTIGACIONES FENOMENOLÓGICAS*: 219.

[42] Leder, Helmut, Benno Belke, Andries Oeberst, and Dorothee Augustin. "A model of aesthetic appreciation and aesthetic judgments." *British journal of psychology* 95, no. 4 (2004): 489-508. https://doi.org/10.1348/0007126042369811

[43] Schindler, Ines, Georg Hosoya, Winfried Menninghaus, Ursula Beermann, Valentin Wagner, Michael Eid, and Klaus R. Scherer. "Measuring aesthetic emotions: A review of the literature and a new assessment tool." *PloS one* 12, no. 6 (2017): e0178899. https://doi.org/10.1371/journal.pone.0178899

[44] Galeazzi, Fabrizio. "3-D Virtual Replicas and Simulations of the Past:"Real" or "Fake" Representations?." *Current Anthropology* 59, no. 3 (2018): 268-286. https://doi.org/10.1086/697489

[45] Aylett, Ruth, and Sandy Louchart. "Towards a narrative theory of virtual reality." *Virtual Reality* 7 (2003): 2-9. https://doi.org/10.1007/s10055-003-0114-9

[46] Silvia, Paul J. "Emotional responses to art: From collation and arousal to cognition and emotion." *Review of general psychology* 9, no. 4 (2005): 342-357. https://doi.org/10.1037/1089-2680.9.4.342

[47] Silvia, Paul J. "Looking past pleasure: anger, confusion, disgust, pride, surprise, and other unusual aesthetic emotions." *Psychology of Aesthetics, Creativity, and the Arts* 3, no. 1 (2009): 48. https://doi.org/10.1037/a0014632

[48] Hashim, Mohd Ekram Alhafis, Muhammad Zaffwan Idris, and Che Soh Said. "The Heptagon of AUX Model: Development of a Synergising Model on Aesthetic Experience and User Experience through the Fuzzy Delphi Method Towards Augmented Reality Comics." In *International Conference on Intelligent Technologies for Interactive Entertainment*, pp. 309-321. Cham: Springer International Publishing, 2021. https://doi.org/10.1007/978-3-030-99188-3_19

[49] Li, Sizhe. "Exploring the Digital Age: The Carrying Capacity of Virtual Reality Technology for Historical and Cultural Heritage." In *2021 3rd International Conference on Economic Management and Cultural Industry (ICEMCI 2021)*, pp. 2162-2166. Atlantis Press, 2021. https://doi.org/10.2991/assehr.k.211209.354

[50] Rose, D., J. R. Martin, K. Maton, and Y. J. Doran. "Accessing Academic Discourse: Systemic Functional Linguistics and Legitimation Code Theory." (2020): 236-267. https://doi.org/10.4324/9780429280726-9

[51] Aylett, Ruth. "Narrative in virtual environments-towards emergent narrative." In *Proceedings of the AAAI fall symposium on narrative intelligence*, pp. 83-86. 1999.

[52] Jankowski, Jacek, and Martin Hachet. "A survey of interaction techniques for interactive 3D environments." In *Eurographics 2013-STAR*. 2013.

[53] Walczak, Krzysztof, Wojciech Cellary, and Martin White. "Virtual museum exbibitions." *Computer* 39, no. 3 (2006): 93-95. https://doi.org/10.1109/MC.2006.108

[54] Kuchelmeister, Volker. "The virtual (reality) museum of immersive experiences." *Electronic Visualisation and the Arts* (2018): 203-210. https://doi.org/10.14236/ewic/EVA2018.39

[55] Jeong, Kisung, Jinmo Kim, Mingyu Kim, Jiwon Lee, and Chanhun Kim. "Asymmetric interface: user interface of asymmetric virtual reality for new presence and experience." *Symmetry* 12, no. 1 (2019): 53. https://doi.org/10.3390/sym12010053

[56] McMahan, Ryan P., Doug Gorton, Joe Gresock, Will McConnell, and Doug A. Bowman. "Separating the effects of level of immersion and 3D interaction techniques." In *Proceedings of the ACM symposium on Virtual reality software and technology*, pp. 108-111. 2006. https://doi.org/10.1145/1180495.1180518

[57] Friedman, Doron, Robert Leeb, Angus Antley, Maia Garau, Christoph Guger, Claudia Keinrath, Anthony Steed, Gert Pfurtscheller, and Mel Slater. "Navigating virtual reality by thought: First steps." In *Proc. 7th Annual Int. Workshop PRESENCE, Valencia*, pp. 160-167. 2004.

[58] Selzer, Matias N., and Silvia M. Castro. "Immersion Metrics for Virtual Reality." *arXiv preprint arXiv:2206.07748* (2022).

[59] Pan, Yongming. "VR Reality of the Relationship between Augmented Reality and Virtual Reality in the Context of Virtual Reality." In *Journal of Physics: Conference Series*, vol. 2066, no. 1, p. 012056. IOP Publishing, 2021. https://doi.org/10.1088/1742-6596/2066/1/012056

[60] Pillai, Jayesh S., Colin Schmidt, and Simon Richir. "Achieving presence through evoked reality." *Frontiers in psychology* 4 (2013): 86. https://doi.org/10.3389/fpsyg.2013.00086

[61] Abd El-Sattar, Hussein Karam Hussein. "A new plot/character-based interactive system for story-based virtual reality applications." *International Journal of image and graphics* 10, no. 01 (2010): 113-133. https://doi.org/10.1142/S021946781000369X

[62] Kritikos, Yannis, and Katerina Mania. "Interactive Historical Documentary in Virtual Reality." In *2022 International Conference on Interactive Media, Smart Systems and Emerging Technologies (IMET)*, pp. 1-8. IEEE, 2022. https://doi.org/10.1109/IMET54801.2022.9929500

[63] Aylett, Ruth, and Sandy Louchart. "Towards a narrative theory of virtual reality." *Virtual Reality* 7 (2003): 2-9. https://doi.org/10.1007/s10055-003-0114-9

[64] Walmsley, Alexander P., and Thomas P. Kersten. "The IMPERIAL Cathedral in Königslutter (Germany) as an immersive experience in virtual reality with integrated 360 panoramic photography." *Applied Sciences* 10, no. 4 (2020): 1517. https://doi.org/10.3390/app10041517

[65] Giangreco, Ivan, Loris Sauter, Mahnaz Amiri Parian, Ralph Gasser, Silvan Heller, Luca Rossetto, and Heiko Schuldt. "Virtue: a virtual reality museum experience." In *Proceedings of the 24th international conference on intelligent user interfaces: companion*, pp. 119-120. 2019. https://doi.org/10.1145/3308557.3308706

[66] Al-Jundi, Hamza A., and Emad Y. Tanbour. "A framework for fidelity evaluation of immersive virtual reality systems." *Virtual Reality* 26, no. 3 (2022): 1103-1122. https://doi.org/10.1007/s10055-021-00618-y

[67] Vinayagamoorthy, Vinoba, Andrea Brogni, Marco Gillies, Mel Slater, and Anthony Steed. "An investigation of presence response across variations in visual realism." In *The 7th Annual International Presence Workshop*, pp. 148-155. 2004.

[68] Immonen, Visa. "3D Modelling of Heritage Objects: Representation, Engagement and Performativity of the Virtual Realm." In *The Palgrave Handbook of Digital and Public Humanities*, pp. 377-396. Cham: Springer International Publishing, 2022. https://doi.org/10.1007/978-3-031-11886-9_20

[69] Gülhan, Doğa. "Aesthetic experience and judgment: exploring three-dimensional arts in real-world, virtual reality, and online settings." PhD diss., Royal Holloway, University of London, 2021.

[70] Gulhan, Doga, Szonya Durant, and Johannes M. Zanker. "Aesthetic judgments of 3D arts in virtual reality and online settings." *Virtual Reality* (2022): 1-17. https://doi.org/10.1007/s10055-022-00671-1