Leveraging Transdisciplinary Engineering in a Changing and Connected World
P. Koomsap et al. (Eds.)

doi:10.3233/ATDE230650

Exploring User Perceptions from the User-Centered Usability Perspective of the Museum Online Virtual Exhibitions

Fazal GILANI[a] , Chang WANG [a], Fan LI[b] and Ching-Hung LEE [a1]
[a] *Xi'an Jiaotong University, School of Public Policy and Administration, China*
[b] *The Hong Kong Polytechnic University, Department of Aeronautical and Aviation Engineering, Hongkong, China*

Abstract. Users' perceptions of online museums' virtual exhibitions still need vivid exploration, public museums are increasingly adopting technological innovations for online virtual exhibitions, but further studies are required to understand how audiences and users respond to them. This preliminary research study aimed to explore users' perceptions of the museum's online virtual exhibition from the user-centered usability perspective, which refers to the process of evaluating products and services based on their usability for users. In this study, we put forth a conceptual and theoretical framework to guide our investigation and employed descriptive statistics and factor analysis. The analysis identifies two key factors, F1 and F2, that influence users' perceptions and reveal their relationship with the examined factors. Factor 1 (F1) reflects user experience (0.612), user ease (0.754), user satisfaction (0.580), and user expectation (0.551) from Scale 1. While displaying an inverse relationship with Scale 2-5 items, including impact on the user (-0.881), user attitude (-0.732), user satisfaction (-0.881), and usefulness of techs (-0.634). Factor 2 (F2) exhibits high loadings for user overall experience (0.930) and user experience of virtual tools (0.657) from Scale 1. These findings indicate the significant influence on how users perceive the experience of the museum's online virtual exhibition. Thus, a comprehensive approach integrating user-centered usability perspectives, user perceptions, and technological innovations, is essential for creating an optimal public museum's online virtual exhibition experience under the transdisciplinary engineering principles.

Keywords. User-centered usability evaluation, Virtual exhibition, Online museum. User perceptions, User-centered usability perspective.

Introduction

Transdisciplinary engineering principles can be best applied by considering user perceptions, leveraging technological innovations, and emphasizing the need for user-friendly design features. This study examines users' perceptions from the user-centered usability perspective, which refers to the process of evaluating products and services based on their usability for users. It also looks at factors such as how easy it is for users to use the product or service, how enjoyable and useful it is for them, and how satisfied they are with their experience. The primary objective is to determine what users think of the museum's online virtual exhibition experiences and any potential enhancements they

[1] Corresponding Author, Mail: leechinghung@xjtu.edu.cn.

deem necessary. To achieve this goal, a survey and interviews have been conducted to collect data on users' opinions and perceptions. The digitalization of museums has led to the emergence of online virtual exhibitions. While these digital experiences can be more immersive and interactive than traditional exhibitions, they suffer from many of the same problems as physical exhibits. From usability issues such as low navigation efficiency and difficulty in information comprehension to inadequate user engagement and a lack of customization, the online virtual exhibition landscape is rife with challenges. This study aimed at exploring users' perceptions from the user-centered usability perspective of the museum's online virtual exhibitions and identifying potential areas for improvement.

Through a survey and interviews, we intend to analyze users' opinions and feedback on existing virtual exhibition experiences to define best practices for the development of future virtual exhibitions. Online virtual exhibitions at museums are collective efforts of transdisciplinarity to develop a rich user experience channel. Therefore, customer or user experience evaluation from a user-centered usability perspective can lead the museum to a better future service and product system. It is still a difficult question of how to control variables such as layout, navigation, content, interactivity, and customization in the current online museum virtual exhibitions that affect the user experience and create users' perceptions about the virtual exhibitions at online digital museum services [1]. Although there are many theoretical and practical obstacles to overcome, digital transformation and the digitalization of museums have been the focus of intense scientific research in recent years, especially since the COVID-19 pandemic [2,3,4,5].

In this study, we have chosen the Shaanxi History Museum's recent virtual exhibition named "*World Heritage Photography Art Exhibition"* [2]. Our research study for an online virtual exhibition reports a preliminary inspection of users' perceptions from a user-centered usability perspective. We have investigated online virtual exhibition users' observatory opinions on virtual technology services as a form of innovation and especially digital innovation at the museum's digital public services in Xi'an, China. The research questions guiding the study were: RQ1: What are users' perceptions of the digital museum's online virtual exhibitions from a user-centered perspective? RQ2: How can museum virtual exhibitions be enhanced based on a usability evaluation of users' perceptions of the digital museum's online virtual exhibitions?

1. Literature Review

1.1. Virtual Museums and Exhibitions in China

Immersive technology has offered novel solutions to presenting design concepts, allowing users to immerse themselves in controllable settings and get a more accurate insight into human responses [6]. Several studies have noted that emerging technologies could be useful for practical utilization in the preservation of Chinese art [7]. Moreover, few extensive studies are focusing on cultural heritage through virtual reality (VR) and augmented reality (AR). Bailenson et al., (2008) found that participants in their research have learned better and even enjoyed learning experiences through virtual reality technology. VR and AR have matured as customer experiences. The museum sector has been investing in management logic to improve effectiveness, efficiency, and economic and administrative balance [9, 10]. VR has become a more and more common form of

[2] http://www.qinling360.com/guangyingzange/

art consumption, but research and discussion are still needed to determine how audiences react to it [11]. Improving users' experiences on an individual level can lead to a proper immersive or virtual exhibition system [12]. Most famous public museums in China have offered online exhibitions and 3D virtual tours on their websites, making these experiences available online, on mobile devices, and through virtual reality (VR) technology. Researchers have explored ways to evaluate the cognitive states of users in real-time and use that data to create adaptive and intelligent virtual reality environments that can respond to the user's experience [13].

1.2. User-centered usability evaluation approach

The widely used usability scales from the user-centered usability perspective, such as the System Usability Scale (SUS), Satisfaction with Information Search Tasks Scale (SIST), and Task Usability Scale (TUS), will enable a comprehensive evaluation of users' perceptions of the museum's online virtual exhibitions, allowing for a more in-depth understanding of the user experience. Specifically, virtual reality VR experience questionnaires, such as the VR experience questionnaire (VEQ) and the NASA Task Load Index (NASA-TLX), provide further insights into the user experience of museum online virtual exhibitions. This will help identify areas for improvement and make recommendations for better user experiences in the future. Usability is one of the many other commonly used assessed variables under user-centered evaluation (UCE) in previous research studies on adaptable systems. Using questionnaires is a widespread method, as is the analysis of interview data [14]. A frequently used identical test for evaluating user perceptions is the System Usability Scale (SUS). According to Lewis and Sauro (2009), the SUS has accounted for 43% of post-research study questionnaire utilization in multiple fields of usability studies. As there are not many research studies available based on users' perceptions from the user-centered usability perspective evaluation of the online virtual exhibition at digital online museums services as Styliani et al., (2009) have also revealed in their study that analyzing the relationship between user experience and online museum virtual services evaluation could to an understanding of "real user" experience. Less studies have been done on museum visits yet.

2. Research Framework

In this study, a conceptual and theoretical framework has been integrated and adapted to the user usability scales as advised [17]. By using the user usability scales provided by Lewis [17] to create our survey questionnaire. we created a survey questionnaire that utilized a five-point Likert scale for responses. And the questionnaire comprised seven items/attributes for Scale 1 and four items/attributes each for Scales 2 to 5, all of which were designed to assess the user-centered usability perspective when evaluating an online virtual exhibition. Furthermore, we adopted the thematic analysis under the qualitative methodology [18], for conducting interviews and collecting data. The recordings of the interviews were transcribed, coded, and subjected to thematic analysis to identify four primary theme attributes. We adopted a descriptive statistics analysis and factor analysis under the quantitative research method to investigate users' perceptions of the digital museum's online virtual exhibitions from a user-centered usability perspective. To collect data, we administered a survey questionnaire comprising five user usability scales. Scale 1 encompassed seven user items/attributes, while scales 2 to 5

included four user items/attributes each. The survey was directed to a sample size of 100 users who were reached out for evaluation. In order to capture the user's perceptions, we conducted our survey on the "World Heritage Photography Art Exhibition" from 01/10/2023 to 24/01/2023, which spanned a period of two weeks. We have estimated that the total number of visitors to this online virtual exhibition during this time frame was no greater than a few hundred. A survey questionnaire online link was sent to participants via Whatsapp and WeChat. Respondents in this study survey were considered voluntary without any remuneration. Survey respondents were approached by a mix of convenience and snowball sampling of the teachers', students', and researchers' networks.

Six online users interviews were also conducted. For a small research project, it is recommended to have 6-10 participants in total for interviews for valid conclusions from a thematic analysis [19]. Considering time limitations We interviewed 6 participants, and each interview remained for approximately 45 minutes. The first 10 minutes were used to introduce and explain the purpose of our research, followed by 20 minutes of exploration of the online virtual exhibition the "World Heritage Photography Art Exhibition". Finally, 15 minutes were allocated to answer questions to analyze users' perceptions of the online virtual exhibition with thematic analysis. In the survey questionnaire, participants were asked to rate "World Heritage Photography Art Exhibition," an online virtual exhibition at the Shaanxi History online digital museum, against these criteria on 5-scale items including S1, (a), (b), (c), (d), (e), and (f) subscale items for scale-1, and items S2, S3, S4, and S5 were under Scale 2-5, as shown in Table 1. and in Figure 1. adapted the user usability scales from [17].

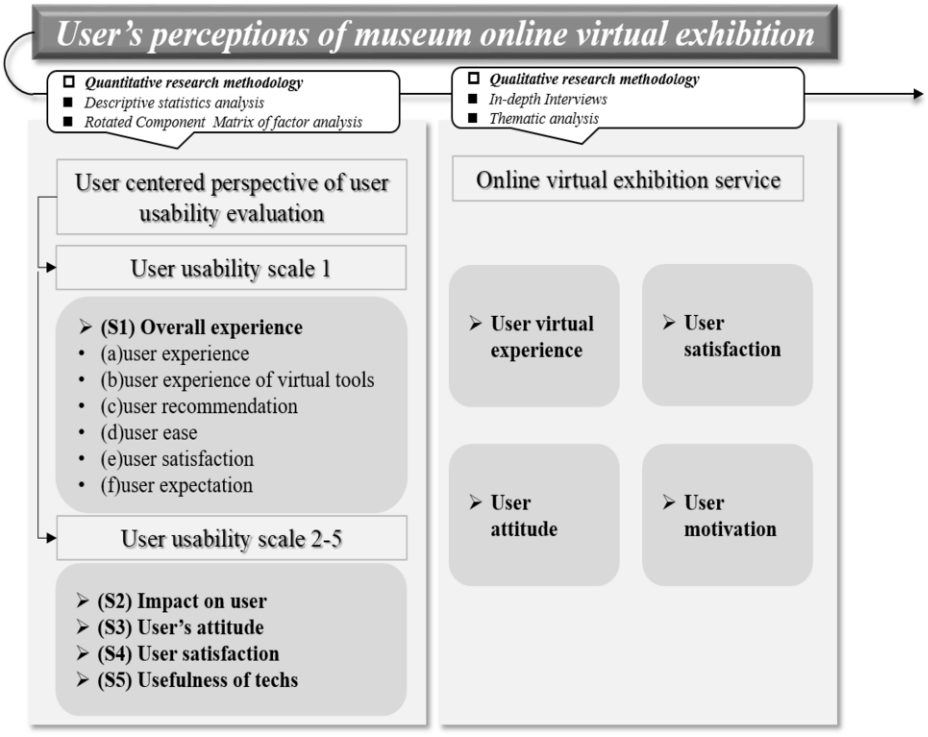

Figure 1. Proposed conceptual & theoretical framework.

Each item of this survey questionnaire was measured on a five-point Likert scale. The difference between item (e) User Satisfaction and S4 User Satisfaction is that item (e) specifically relates to the virtual exhibition under consideration, whereas S4 is an overall measurement of the user's satisfaction with the service provided by the digital museum.

Table 1. Corresponding measurement items for the museum's online virtual exhibition.

Attributes/Items	Code	Questions
Overall Experience	S1	How likely is it that you would endorse "World Heritage Photography Art Exhibition" online virtual exhibition services to your friends, family, and colleagues based on your overall experience?
User Experience	(a)	Do you think the "World Heritage Photography Art Exhibition" museum's online virtual exhibition has provided you satisfactory user experience without any problems?
User Experience of virtual tools	(b)	Based on your virtual tools experience of the World Heritage Photography Art Exhibition "virtual tour. Do you believe that audio narration guidance, social media live sharing, virtually inviting friends and family members, virtual communication tools, and recording or taking photos of your virtual tour for an online virtual exhibition should be provided?
User Recommendation	(c)	While virtual touring of World Heritage Photography Art Exhibition. Did you feel lonely? Would you recommend this virtual exhibition tour to your other friends?
User Ease	(d)	Does Shaanxi History Museum's recent virtual exhibition named "World Heritage Photography Art Exhibition" decrease the difficulties you usually feel during real physical museum exhibitions by increasing the ease of visitors to virtual exhibitions?
User Satisfaction	(e)	Do you think the virtual exhibition of the "World Heritage Photography Art Exhibition" was a satisfactory service for digital public services at the public museum level in Xi'an, China?
User Expectation	(f)	Please estimate your World Heritage Photography Art Exhibition virtual exhibition experience, based on your usage expectations, will you come to use more virtual exhibitions in the Post-Covid era?
Impact on User	S2	How well have World Heritage Photography Art Virtual Exhibition services left an impact on you?
User Attitude	S3	How responsive has the "World Heritage Photography Art Virtual Exhibition" been to your personal virtual experience?
User Satisfaction	S4	How likely are you satisfied with the "World Heritage Photography Art Virtual Exhibition" services?
Usefulness of Techs	S5	After the virtual tour of the "World Heritage Photography Art Virtual Exhibition", what do you think how useful are new immersive technologies like "Virtual Reality" to showcase and preserve heritage photography art?

2.1. Measurement

Prior to administering the survey, we validated our survey questions by using seven participants. The collected 100 responses were then analyzed through statistical assessments to ensure their reliability and validity. Specifically, we evaluated the reliability of measurement items using the corrected item-total correlation and alpha coefficient, and subsequently conducted factor analysis.

3. Results

3.1. Descriptive statistics of item responses

Data collected from 100 participants with an overall mean of 3.1482, with a standard deviation of 0.28709 showed a normal distribution of skewness and kurtosis values

ranging between -1 and 1. The majority of respondents (65%) were male, with 30% between the ages of 18-24, and 52% of those being students. Respondents reported using computer skills on a daily or almost daily basis (62%), with 47% reporting intermediate-level skills, 31% advanced skills, and 22% expert skills. Overall, the skewness value was -.276 and the kurtosis was -1.98, indicating that the measurement was valid.

Table 2. Results of descriptive statistics.

	Category	**Frequency**	**Percentage**
Age	18-24	30	30%
	25-30	28	28%
	31-35	17	17%
	36-40	15	15%
	41-50	10	10%
Gender	Female	35	35%
	Male	65	65%
Status	Student	52	52%
	Researcher	29	29%
	Practitioner	17	17%
	Other	2	2%
Level of Computer Skills	Intermediate level (know one or two programs well, need some help)	47	47%
	Advanced level (know a number of programs, including advanced functions, learn easily)	31	31%
	Expert level (know a number of programs, including advanced functions, able to provide help)	22	22%
Use Frequently	Daily or Almost Daily	62	62%
	Once or Twice a Week	18	18%
	Once or Twice a Month	10	10%
	Once or Twice a Year	10	10%

3.2. Reliability

As seen in Table 3. An evaluation of the items in Scale 1 (S1, a-f) and Scale 2-5 (S2-S5) showed good reliability, analyzing the reliability of each item on two different scales. It shows the corrected item-total correlation and Cronbach's alpha for Scale 1 (S1, a-f) with N = 7 and for Scale 2-5 with N = 4. For both scales, the correlations range from 0.500 to 0.821 and the alphas range from 0.825 to 0.880. This suggests that the items are reliable across both scales. Overall, Cronbach's alpha for items in Scale 1 (S1, a-f) was 0.851 with N=7, while those in Scale 2-5 (S2-S5) were 0.885 with N=4. We find that the reliability of items at both scales is excellent [20].

Our study further examined the construct of user perceptions by using a factor analysis based on the conceptual and theoretical framework of this study to determine whether the total of 5 user usability scales from the user-centered usability perspective evaluation of the museum's online virtual exhibition can be clarified by the 11 measurement items related to users' perceptions.

3.3. Construction of user perceptions

To explore the construct validity of the instruments, we conducted a factor analysis based on our conceptual and theoretical framework. We attempted to assess if the study's framework of user-centered usability perspective evaluation of the museum's online virtual exhibition's five usability scales could be explained by the eleven measurement

items/attributes. The results of factor analysis revealed two factors F1 and F2 that accounted for 63.528% of the total variance with an eigenvalue of 1.011. Additionally, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.879 and the Barlett's test of approximated chi-square was 629.853, with a significance level of $p < 0.000$.

Table 3. Test the reliability discriminant of each item and internal consistency, reliability of the scale, and reliability analysis if deleted.

Items	Corrected Item-Total correlation by Scale 1 (A)	Cronbach's alpha if deleted by Scale 1 (B)	∝, N =7 (C)	Items	Corrected Item-total correlation by a Scale 2-5 (D)	Cronbach's alpha if deleted by Scale 2-5 (E)	∝, N= 4 (F)
S1 Overall Experience	0.682	0.819		S2 Impact on User	0.730	0.860	
(a) User Experience	0.641	0.826	0.851	S3 User Attitude	0.773	0.843	0.885
(b) User Experience of virtual tools	0.500	0.845		S4 User Satisfaction	0.821	0.825	
(c) User Recommendation	0.591	0.833		S5 Usefulness of Techs	0.678	0.880	
(d) User Ease	0.589	0.833					
(e) User Satisfaction	0.642	0.827					
(f) User Expectation	0.658	0.825					

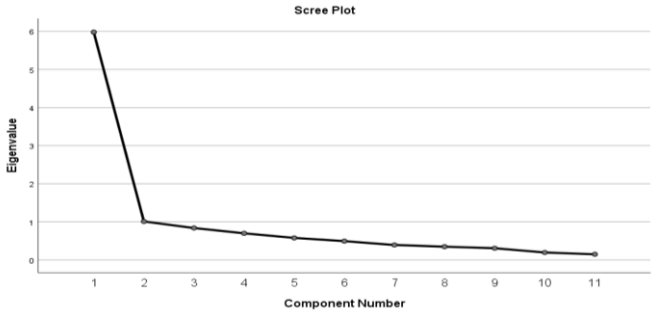

Figure 2. Scree plot of user perceptions in the museum's online virtual exhibition.

"User perception of the museum's online virtual exhibitions F1 and F2", Table 4. shows the rotated component matrix obtained from a factor analysis using principal component analysis with the Varimax rotation method and Kaiser normalization. To determine the factor structure of user perceptions of the museum's online virtual exhibition, we examined factor loadings with absolute values below 0.55., In Factor 1 (F1) representing user-centered usability perspective evaluation, Scale 1 items, including user experience 0.612 (a), user ease 0.754 (d), user satisfaction 0.580 (e), and user

expectation 0.551 (f), exhibited factor loadings above 0.55. Moreover, there was an inverse relationship between F1 and Scale 2-5 items, indicating factor loadings such as the impact on the user -.881 (S2), user attitude -.732 (S3), user satisfaction -.881 (S4), and usefulness of techs -.634 (S5) significantly influenced user perceptions of the online virtual exhibition.

Factor 2 (F2), also derived from user-centered usability perspective evaluation, had high factor loadings for Scale 1 item user overall experience 0.930 (S1) and user experience of virtual tools 0.657 (b). These findings suggest that users' overall experience and their experience with virtual tools significantly contribute to their perceptions of the online virtual exhibition. These results disclose that the user-centered usability perspective evaluation of the museum's online virtual exhibition has been appropriately made with scales 1-5 measurement items/attributes to explore users' perceptions of the online museum virtual exhibition.

Based on the results of the factor analysis, we were able to answer our study's research questions RQ1 and RQ2, it appears that items from scale 1 S1, (a), (b), (d), (e), (f) and from scale 2-5 S2, S3, S4 and S5 have a significant influence including an inverse influence on how users perceive museum's online virtual exhibition. By knowing the user perceptions, enhancements in museum virtual exhibition services can be provided by focusing on these areas. There is a significant influence including an inverse relation between user perception of the museum's online virtual exhibition and attributes such as the impact on the users, user attitude, user satisfaction, and usefulness of tech attributes. Enhancing online virtual exhibition services based on user perceptions can result in an improved user experience that can increase adoption at the public level. The overall findings from the factor analysis emphasize the importance of adopting a user-centered usability perspective. By continuously evaluating users' perceptions and incorporating their feedback into the design and development process, virtual exhibitions can be enhanced to better meet users' needs and preferences.

Table 4. Factor analysis of user perceptions in the museum's online virtual exhibition, Rotated component matrix.

Scales	Items	user perception of the museum's online virtual exhibition – F1	user perception of the museum's online virtual exhibition - F2
Scale 1	S1=Overall Experience		0.657
	(a)=User Experience	0.612	
	(b)=User Experience of virtual tools		0.930
	(c)=User Recommendation		
	(d)=User Ease	0.754	
	(e)=User Satisfaction	0.580	
	(f)=User Expectation	0.551	
Scale 2-5	S2=Impact on User	-.881	
	S3=User Attitude	-.732	
	S4=User Satisfaction	-.881	
	S5=Usefulness of Techs	-.634	

3.4. Thematic analysis

The interview guide for the museum's online virtual exhibition services involved knowing user perceptions of user virtual experience, satisfaction, attitude, and motivation. Once data was collected, coding and thematic analysis were conducted.

Interview recordings were transcribed and coded to identify four primary theme attributes: user virtual experience, user satisfaction, user attitude, and user motivation.

1. User virtual experience: Almost all six interview participants reported that their user experience of this virtual exhibition was good.

2. User satisfaction: Four interview participants highlighted that this virtual exhibition somewhat did a job of meeting their satisfactory user experience.

3. User Attitude: The third theme is based on user attitude to know their perceptions about the virtual exhibition interface, interaction, and responsiveness. Almost all participants responded online virtual exhibitions could be made more interactive and responsive by making some improvements.

4. User Motivation: The Fourth theme was based on participants' motivations about the use of virtual exhibitions in the future. All participants were somewhat motivated to see these virtual exhibitions in the coming future under different circumstances.

We were able to answer our study's research questions RQ1 and RQ2 as users find the online virtual exhibition to be a positive, engaging, and enriching experience. Generally, people find online virtual exhibitions to be enjoyable, but they still appreciate the physical presence of a museum or gallery. Overall, the thematic analysis suggests that museum virtual exhibitions can be enhanced by focusing on improving user experience, addressing user satisfaction, incorporating interactivity and responsiveness, and considering users' motivations for future engagement. A usability evaluation that takes into account users' perceptions can provide valuable guidance for enhancing the digital museum's online virtual exhibitions.

4. Discussion and Conclusion

The results of this study establish the importance of taking user perception into account from a user-centered usability perspective. The findings of this research support the conclusion that there is a significant influence including an inverse relation between user perception of the museum's online virtual exhibition and attributes such as the impact on the users, user attitude, user satisfaction, and usefulness of tech attributes. Enhancing online virtual exhibition services based on user perceptions can result in an improved user experience.

Finally, this research provides insight into how users perceive museums' online virtual exhibitions and highlights the potential benefits of such experiences. Through this study, we have taken a step towards furthering the understanding of user perceptions within digital museum settings and providing direction for future research. This research study has provided both academic and practical contributions. Academically, this study has established an understanding of user perceptions within digital museum settings by exploring them from a user-centered usability perspective and providing insight into how users perceive and experience online virtual exhibitions. Practically, this research has proposed user-centered perspectives based on user usability evaluation measurement items that could help museums enhance their online public digital services for virtual exhibitions.

Transdisciplinary engineering involves considering user perception, leveraging technological innovations, and integrating different technologies to adapt a personalized user experience. Whereas, voice-of-the-customer insights are used to identify users' needs and preferences. This allows the creation of an online virtual exhibition that reaches its full potential [21]. There are still certain research limitations that should be

considered when interpreting the results. For instance, the sample size of the study was not large enough to provide a generalizable view of the overall user population. As the study was primarily focused on knowing users' perceptions of digital museums' online virtual exhibitions, the scope of this research was limited to the particular case study.

References

[1] L. Meng, Y. Liu, K. Li and R. Lyu, Research on a User-Centered Evaluation Model for Audience Experience and Display Narrative of Digital Museums. *Electronics*, 2022, 11(9), 1445.
[2] P. Lo, H.H. Chan, A.W. Tang, D.K. Chiu, A. Cho, E.W. See-To, K.K. Ho, M. He, S. Kenderdine and J. Shaw, Visualising and revitalising traditional Chinese martial arts. *Library Hi Tech*, 2019, 37(2), 273–292.
[3] C.H. Lee, D. Wang, K.C. Desouza and R. Evans, Digital Transformation and the New Normal in China: How Can Enterprises Use Digital Technologies to Respond to COVID-19? *Sustainability*, 2021, 13(18), 10195.
[4] X. Sun, D.K.W. Chiu and C.T. Chan, Recent Digitalization Development of Buddhist Libraries. *The Digital Folklore of Cyberculture and Digital Humanities*, 2022, pp. 251–266.
[5] M.Y.C. Mak, A.Y.M. Poon and D.K.W. Chiu, Using Social Media as Learning Aids and Preservation. *The Digital Folklore of Cyberculture and Digital Humanities*, 2022, pp. 171–185.
[6] F. Li, A.J. Trappey, C.H. Lee and L. Li, Immersive technology-enabled digital transformation in transportation fields: A literature overview. *Expert Systems With Applications*, 2022, Vol. 202, 117459.
[7] L. Ma and X. Lu, The VR Museum for Dunhuang Cultural Heritage Digitization Research. In *Conference Proceedings of Conference on Cultural Heritage and New Technologies. ICOMOS*. Austria, 2021, November, pp. 1-4.
[8] J. Bailenson, K. Patel, A. Nielsen, R. Bajscy, S.H. Jung and G. Kurillo, The Effect of Interactivity on Learning Physical Actions in Virtual Reality. *Media Psychology*, 2008, 11(3), pp. 354–376.
[9] S. Chen, Z. Pan and M. Zhang, A virtual informal learning system for Cultural Heritage. *Transactions on Edutainment VII*, 2012, pp. 180–187.
[10] L. Solima and A. Minguzzi, Territorial development through cultural tourism and creative activities. *Mondes Du Tourisme*, 2014, 10, pp. 6–16.
[11] Y. Kim and H. Lee, Falling in Love with Virtual Reality Art: A New Perspective on 3D Immersive Virtual Reality for Future Sustaining Art Consumption. *International Journal of Human–Computer Interaction*, 2021, 38(4), pp. 371–382.
[12] R. Mabrook and J.B. Singer, Virtual Reality, 360° Video, and Journalism Studies: Conceptual Approaches to Immersive Technologies. *Journalism Studies*, 2019, 20(14), pp. 2096–2112.
[13] F. Li, C.-H. Lee, S. Feng, A. Trappey and F. Gilani, Prospective on eye-tracking-based studies in immersive virtual reality. *2021 IEEE 24th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, 2021, DOI: 10.1109/CSCWD49262.2021.9437692.
[14] L. Van Velsen, T. Van Der Geest, R. Klaassen and M. Steehouder, User-centered evaluation of adaptive and adaptable systems: a literature review. *The knowledge engineering review*, 2008, 23(3), pp. 261-281.
[15] J.R. Lewis and J. Sauro, The factor structure of the system usability scale. In *Human Centered Design: First International Conference, HCD 2009, Held as Part of HCI International 2009, San Diego, CA, USA, July 19-24, 2009 Proceedings 1*, Springer, Berlin Heidelberg, 2009, pp. 94-103.
[16] S. Styliani, L. Fotis, K. Kostas and P. Petros, Virtual museums, a survey and some issues for consideration. *Journal of Cultural Heritage*, 2009, 10(4), pp. 520–528.
[17] J.R. Lewis, The System Usability Scale: Past, Present, and Future. *International Journal of Human–Computer Interaction*, 2018, 34(7), pp. 577–590.
[18] M. Bastan, M. Zarei and R. Tavakkoli-Moghaddam, A new technology acceptance model: a mixed-method of grounded theory and system dynamics. *Kybernetes*, 2022, Vol. 51(1), pp. 1–30.
[19] V. Braun and V. Clarke, *Successful qualitative research: A practical guide for beginners*. Sage, London, 2013.
[20] J.A. Gliem and R.R. Gliem, Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. *Midwest research-to-Practice Conference in Adult, Continuing, and community education*, 2003.
[21] S. Lattanzio, A. Nassehi, G. Parry and L. Newnes, Concepts of transdisciplinary engineering: a transdisciplinary landscape. *International Journal of Agile Systems and Management*, 2021, Vol. 14(2), pp. 292-312.