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A Study on the Factors Influencing Learner Satisfaction in Metaverse Learning

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Abstract

This study explores the influence of presence, interactivity, cyber sickness, and loading time on learner satisfaction within metaverse learning environments. Given the burgeoning interest in virtual educational platforms, understanding these factors is critical for developing effective digital learning spaces. The purpose of this research is to ascertain how each factor distinctly contributes to enhancing or diminishing learner satisfaction. Employing Partial Least Squares Structural Equation Modeling(PLS-SEM) on data collected from users of a specific metaverse platform, the study confirms that presence and interactivity significantly enhance satisfaction, while cyber sickness negatively impacts it. Conversely, loading time was found to have no significant effect on learner satisfaction. The study suggests that rather than focusing on technical performance such as loading speeds, developers and educators should prioritize enriching the quality of user interactions and presence within the virtual learning context.

요 약

본 연구는 메타버스 학습 환경 내에서 존재감, 상호작용성, 사이버멀미, 로딩시간이 학습자 만족도에 미치는 영향을 분석하였다. 가상교육 플랫폼에 대한 관심이 급증하고 있는 상황에서, 이러한 요인들을 이해하는 것은 효과적인 디지털 학습 공간을 개발하는 데 매우 중요하다. 본 연구의 목적은 각 요인들이 학습자 만족도를 높이거나 낮추는 데 어떻게 영향을 미치는 지를 규명하는 것이다. 본 연구는 특정 메타버스 학습 플랫폼 사용자로부터 수집한 데이터를 부분 최소제곱 구조방정식 모델링을 적용하여 실증적으로 분석하였다. 연구 결과, 존재감과 상호작용성이 만족도를 크게 향상시키는 반면, 사이버멀미는 만족도에 부정적인 영향을 미쳤다. 반면 로딩시간은 학습자 만족도에 유의미한 영향을 미치지 않는 것으로 나타났다. 이러한 결과는 사이버멀미로 인한 불편함을 최소화하면서 상호작용적이고 몰입적인 경험을 최적화하는 메타버스 환경 설계의 중요성을 강조한다. 본 연구는 개발자와 교육자가 로딩속도와 같은 기술적 성과에 초점을 맞추기보다는 가상학습 맥락 내에서 사용자 상호작용과 존재감의 질을 강화하는 데 우선순위를 두어야 함을 시사한다.

Keywords

cyber sickness, interactivity, learner satisfaction, metaverse, presence, virtual learning environments

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Ⅰ. Introduction

The rapid advancement of Virtual Reality(VR) technologies has led to the burgeoning development of metaverse environments where immersive, interactive digital experiences are becoming the norm[1]-[3]. In educational settings, these metaverse platforms are increasingly seen as a frontier for innovative learning methods, merging the physical and digital worlds in ways that fundamentally alter how knowledge is conveyed and absorbed. Research into the adoption and effectiveness of such technologies in education has gained momentum, particularly focusing on how these virtual environments can enhance learning experiences[4].

One of the core elements that influence the effectiveness of these virtual learning environments is presence, defined as the subjective experience of being in one place even when one is physically situated in another. Studies have demonstrated that a heightened sense of presence can significantly increase engagement and learning outcomes[5].

Interactivity in learning platforms has also been highlighted as a crucial factor in educational satisfaction and effectiveness. It allows learners to manipulate their learning environment and engage actively with content, which leads to deeper learning and retention[6].

However, the immersion in virtual environments can also lead to cyber sickness, a condition characterized by symptoms such as nausea, headache, and disorientation, which arises from the sensory conflict experienced in VR. The occurrence of cyber sickness has been identified as a potential barrier to the effective use of educational technologies in metaverse environments[7]. Additionally, technical aspects such as loading time can significantly impact user satisfaction. In the context of educational metaverse applications, where seamless interaction is critical, delays can disrupt the learning flow and negatively affect the overall experience[8].

This paper aims to explore how presence, interactivity, cyber sickness, and loading time impact learner satisfaction within a metaverse learning environment. By utilizing a Structural Equation Modeling(SEM) approach, this study intends to provide empirical insights into the relationships among these variables. The implications of this research are significant, not only for the design and implementation of effective educational technologies but also for the broader theoretical understanding of learning dynamics in virtual realities.

The metaverse, as a complex and multi-dimensional space, offers unique opportunities and challenges for education. This study's findings are expected to contribute to the optimization of metaverse platforms, enhancing user engagement and minimizing the negative effects of cyber sickness and technical inefficiencies. Furthermore, by shedding light on the crucial factors that affect learner satisfaction, this research will inform future developments in VR-based education, ensuring that these technologies are used to their full potential to facilitate effective and enjoyable learning experiences.

Ⅱ. Theoretical Development and Research Hypotheses

The theoretical framework of this study is grounded in the Technology Acceptance Model(TAM) and the Media Richness Theory(MRT). TAM posits that perceived usefulness and perceived ease of use are fundamental determinants of technology adoption and user satisfaction[9]. This model supports the inclusion of factors like interactivity, which enhance ease of use, and loading times, which may detract from perceived usefulness due to inefficiency. MRT complements this by suggesting that the communication medium's ability to reproduce the information sent over it affects user satisfaction[10].

MRT is particularly relevant in explaining why presence and cyber sickness are crucial; a richer media environment enhances the sense of presence, thereby increasing satisfaction, while cyber sickness, a result of poor media richness(e.g., latency or lack of fidelity), decreases satisfaction.

By integrating these theories, the research model addresses how each factor uniquely contributes to the learning experience in the metaverse, highlighting their combined impact on overall learner satisfaction. Figure 1 depicts the research model.

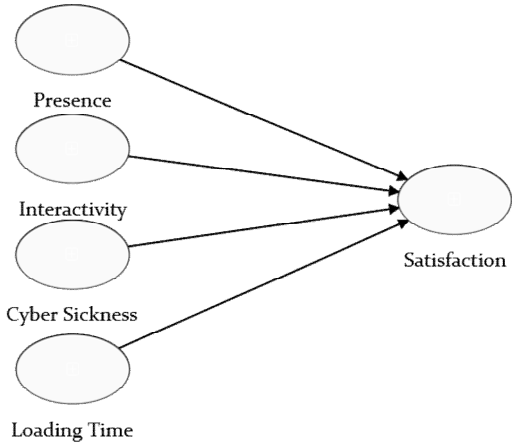

Fig. 1. Research model

2.1 Presence

Presence in a metaverse learning environment is described as the sense of "being there" within a virtual space, which is crucial for immersive learning experiences[11]. Research in virtual learning contexts highlights that when learners feel more present in such environments, they are more likely to report higher satisfaction due to enhanced engagement and interaction with the content[12][13]. Similarly, studies have found that satisfaction in educational settings is heavily influenced by the quality of the immersive experience, suggesting a direct correlation between the sense of presence and overall satisfaction[14][15]. Thus, this study suggests the following hypotheses.

H1. Presence positively affects Satisfaction.

2.2 Interactivity

Interactivity in educational technology is characterized by the dynamic interaction between learners and digital content, which facilitates active learning and engagement[11]. It has been consistently shown that higher levels of interactivity can lead to increased learner satisfaction, as these interactions make learning experiences more personalized and responsive[16][17]. This positive association is supported by the premise that more engaging and interactive environments contribute significantly to positive educational outcomes, including learner satisfaction[18]. Thus, this study suggests the following hypotheses.

H2. Interactivity positively affects Satisfaction.

2.3 Cyber sickness

Cyber sickness, characterized by symptoms such as dizziness, nausea, and eye strain, typically arises from immersive digital environments[19]. Research indicates that experiencing cyber sickness can significantly detract from user satisfaction, as discomfort directly undermines the usability and overall experience of learning technologies[20][21]. This inverse relationship is further emphasized in studies linking the severity of cyber sickness symptoms to reduced satisfaction and hindered learning outcomes[22][23]. Thus, this study suggests the following hypotheses.

H3. Cyber sickness negatively affects satisfaction.

2.4 Loading time

Loading time refers to the duration it takes for digital content and interfaces to become fully operational and accessible to the user[24]. Studies have shown that prolonged loading times can lead to frustration and a decrease in user satisfaction, as delays disrupt the learning flow and reduce the

efficiency of the educational experience[25][26]. The negative impact of loading time on satisfaction is significant, suggesting that smoother, quicker access to learning resources is crucial for maintaining learner engagement and satisfaction. Thus, this study suggests the following hypothesis.

H4. Loading time negatively affects satisfaction.

III. Empirical Methodology

3.1 Instrument development

For this study, the questionnaire design included two distinct parts, utilizing a five-point Likert scale ranging from "strongly disagree" to "strongly agree" to measure responses. The first part collected demographic information, including age, gender, education level, and prior experience with metaverse platforms. The second part assessed users' perceptions of the main constructs related to the metaverse learning environment. The questionnaire items were initially developed in Korean to ensure clarity and relevance to the local context, drawing from existing validated scales and literature[11][19][24][27][28]. Table 1 organizes the questionnaire items into five key constructs. For instance, the presence construct includes items such as the learner's sense of being in a metaverse environment and recognizing its difference from the real world.

3.2 Subjects and data collection

The target sample for this study comprised students from Tech university of Korea currently enrolled in either the 'Future VR Lab' course or the 'Meeting with a Robotics Celebrity' lecture. These subjects were selected as they represent a technologically engaged demographic likely to have familiarity with metaverse environments, enhancing the relevance and applicability of the findings to educational technologies.

The survey was conducted from April 20, 2022, to May 13, 2022, using both online and offline methods to ensure broad participation. Data collection was performed through an online survey distributed via Naver Form, a platform chosen for its accessibility and ease of use, which is crucial for maximizing response rates. The voluntary nature of participation was emphasized, and anonymity was strictly maintained to protect respondent privacy and encourage honesty in responses.

Table 1. List of constructs and Items

Construct	Item	Description	Reference
Presence	PRC1	The learner has a sense of being in a Metaverse learning environment.	[28]
	PRC2	The learner recognizes that the Metaverse learning environment differs from the real world.	
	PRC3	The experience of the Metaverse Learning Environment is memorable.	
Interactivity	ITA1	Manipulating the Metaverse Learning Content feels clear and easy.	[11]
	ITA2	The overall content structure of the Metaverse Learning Content is easy to understand.	
	ITA3	Metaverse learning content makes it easy for learners to obtain the information they need.	
Cyber sickness	CYS1	I have experienced eye strain while learning in the Metaverse.	[19]
	CYS2	I feel dizzy while learning in the Metaverse.	
	CYS3	I felt motion sickness while learning in the Metaverse.	
Loading time	LOA1	It takes a long time to warm up my device before I can learn in the Metaverse.	[24]
	LOA2	My interaction with the learning content is delayed when learning in the Metaverse.	
Satisfaction	SAT1	Overall, I am satisfied with the experience of learning in the Metaverse.	[27]
	SAT2	I would recommend learning in the Metaverse to others.	
	SAT3	I would use learning in the Metaverse in the future.	

A total of 151 responses were initially collected. After data preprocessing to ensure quality and accuracy, 55 responses were removed due to incompleteness or random answering patterns. Consequently, 96 responses were retained for the final analysis. This filtering process was essential to maintain the integrity and reliability of the data used in the study. The sample size of 96 for this study is considered adequate for the analysis, given the complexity of the model which includes 5 latent variables and 14 observed variables. According to guidelines Wolf, Harrington[29], a minimum sample size of 10 times the largest number of structural paths directed at a single latent variable in the model is suggested. This rule ensures sufficient statistical power for the analysis and valid results.

Table 2 categorizes 96 respondents by gender and academic grade, showing that 63.5% were male and 42.7% were seniors, reflecting a diverse yet academically mature sample.

Table 2. Profile of the respondents

Category	Subject	Frequency	Percentage
Gender	Male	61	63.5%
	Female	35	36.5%
Grade	Freshman	20	20.8%
	Sophomore	9	9.4%
	Junior	26	27.1%
	Senior	41	42.7%

IV. Analysis and Results

This study employed Partial Least Squares SEM (PLS-SEM) to analyze the data, a method particularly suited for exploratory research where the goal is theory building[30]. PLS-SEM is effective for complex models and when the sample size is relatively small, which makes it appropriate given the nature of our research and the number of responses analyzed[31].

4.1 Measurement model

The measurement model assessment in this study utilized factor analysis and reliability tests, confirming the validity and reliability of the constructs. Each construct's reliability was verified through Cronbach's Alpha, Composite Reliability(CR), and Average Variance Extracted(AVE) scores, all detailed in Table 3. Presence, interactivity, cyber sickness, loading time, and satisfaction demonstrated high internal consistency, with Cronbach's Alpha values well above the acceptable threshold of 0.7, indicating substantial reliability[32]. Furthermore, the factor loadings for all items were notably strong, significantly exceeding the recommended threshold of 0.7, suggesting that the items were well-suited to measure the intended constructs[33]. The AVE values for each construct were above 0.5, confirming adequate convergent validity, which measures the extent to which items of a specific construct converge in comparison to measures of different constructs.

Table 3. Factor analysis and reliability

Construct	Item	Mean	St. Dev.	Factor loading	Alpha	CR	AVE
Presence	PRC1	3.417	0.874	0.963	0.952	0.969	0.912
	PRC2	3.479	0.989	0.942			
	PRC3	3.354	0.841	0.960			
Interactivity	ITA1	3.948	0.993	0.967	0.967	0.979	0.939
	ITA2	3.865	0.942	0.964			
	ITA3	3.885	0.999	0.976			
Cyber sickness	CYS1	2.656	1.180	0.966	0.974	0.983	0.950
	CYS2	2.490	1.146	0.981			
	CYS3	2.385	1.185	0.978			
Loading time	LOA1	2.292	1.089	0.988	0.955	0.977	0.954
	LOA2	2.219	1.129	0.966			
Satisfaction	SAT1	3.750	1.000	0.988	0.983	0.989	0.967
	SAT2	3.750	1.051	0.986			
	SAT3	3.740	1.013	0.976			

Table 4 provides the correlation matrix along with discriminant assessment, where the diagonal elements represent the square root of AVE and confirm that all constructs share more variance with their indicators than with other constructs, thereby establishing discriminant validity[33].

Table 4. Correlation matrix and discriminant assessment

Construct	1	2	3	4	5
1. Presence	0.955				
2. Interactivity	0.229	0.969			
3. Cyber sickness	-0.025	-0.076	0.975		
4. Loading time	0.059	-0.120	0.243	0.977	
5. Satisfaction	0.414	0.599	-0.349	-0.167	0.983

Note: Diagonal elements are the square root of AVE.

4.2 Structural model

SEM analysis was performed to evaluate and verify the proposed relationships between the constructs of this study. A bootstrap resampling technique, utilizing 5000 resamples, was employed to determine the significance of the hypotheses in the research model. The outcomes of this analysis are detailed in Table 5.

Table 5. Significance testing results of the structural path coefficients

H	Cause	Effect	β	T	P	Result
H1	Presence	Satisfaction	0.295	4.516	0.000	Supported
H2	Interactivity	Satisfaction	0.503	5.962	0.000	Supported
H3	Cyber sickness	Satisfaction	-0.290	4.055	0.000	Supported
H4	Loading time	Satisfaction	-0.054	0.711	0.239	Not supported

V. Discussion

TThe analysis shows a positive correlation between presence in a metaverse learning environment and satisfaction, with a coefficient of 0.295 and a statistically significant p-value ($p < 0.001$). This result supports the hypothesis that higher levels of perceived presence enhance user satisfaction. The finding aligns with previous research[11][12], who reported that a strong sense of presence tends to increase engagement and overall satisfaction. This effect can be attributed to the immersive nature of the metaverse, where a higher sense of being there enriches the learning experience, making it more engaging and fulfilling. This consistency with prior studies underscores the importance of presence as a critical factor in designing effective metaverse learning environments.

Regarding interactivity, the coefficient of 0.503 indicates a robust positive impact on satisfaction, which is also statistically significant ($p < 0.001$). This finding is the strongest among all the constructs tested, suggesting that interactivity is a key driver of satisfaction in metaverse learning settings. This complements findings from past studies[16][17], who found that interactive elements in educational technology significantly enhance learner satisfaction by making the experience more personalized and engaging. The substantial effect of interactivity on satisfaction demonstrates that enabling dynamic interactions within the metaverse not only supports learning objectives but also significantly enhances learner enjoyment and contentment.

The relationship between cyber sickness and satisfaction is notably negative, with a coefficient of -0.290, confirming the hypothesis with statistical significance ($p < 0.001$). This result resonates with the findings of former works[20][21], highlighting that symptoms like dizziness, nausea, and eye strain detract from the overall satisfaction by affecting user comfort and engagement. The negative impact of cyber sickness suggests that despite the technological advancements in creating immersive learning environments, user comfort remains a pivotal aspect that can significantly hinder the effectiveness of such educational settings.

Contrary to the other factors, the influence of loading time on satisfaction was not supported (β = -0.054, p = 0.239). This lack of statistical significance suggests that loading times may not be as critical to satisfaction as initially anticipated, which is contrary to earlier assumptions[25][26], who reported a negative impact on user experience due to prolonged waiting periods. The minimal influence of loading time in this study might indicate that learners are willing to tolerate longer load times if the overall quality and interactivity of the learning environment are sufficiently compelling.

VI. Conclusion

6.1 Theoretical contribution

This study contributes to the existing literature on metaverse learning by exploring the nuanced relationships between various factors and satisfaction. Previous studies have primarily focused on isolated aspects of learner satisfaction in virtual environments, such as presence or interactivity[11][17]. However, they often did not fully explore the combined effects of cyber sickness and loading times alongside these factors. Our comprehensive approach reveals the interdependencies and collective impact of these variables on satisfaction within the metaverse. The empirical findings underscore the critical role of presence and interactivity in enhancing learner satisfaction. This research bridges that gap by providing a holistic view of how these elements interact and influence learner satisfaction within the metaverse.

A significant theoretical advancement of this study is the understanding of how cyber sickness negatively impacts satisfaction, an area less covered in prior research. While previous studies have acknowledged the discomfort caused by cyber sickness[20][21], they did not fully quantify its direct impact on learning satisfaction compared to other variables like presence and interactivity. The findings of this study suggest that mitigating cyber sickness is just as crucial as enhancing presence and interactivity for improving learner satisfaction.

Additionally, the non-significant impact of loading time on satisfaction contradicts previous assumptions [25][26], indicating that users may prioritize content quality over speed, which shifts the focus for future technology enhancements. This revelation prompts a shift in how developers might prioritize elements of metaverse design, suggesting a potential reevaluation of resource allocation towards enhancing interactive and immersive qualities rather than merely reducing loading times. By presenting these nuanced insights, this study not only guides future empirical and theoretical work but also assists practitioners in designing more effective and satisfying metaverse learning environments.

6.2 Practical implication

The practical implications of this research are profound for various stakeholders in the realm of educational technology, particularly in metaverse learning environments. For educational institutes, the findings suggest that investing in technologies that enhance presence and interactivity should be a priority, as these factors are strongly associated with increased learner satisfaction. Providing students with immersive and interactive learning experiences can lead to higher engagement and potentially better educational outcomes.

For metaverse developers, the study underscores the importance of addressing cyber sickness by optimizing system performance and enhancing user interface design to minimize discomfort. Such improvements can significantly enhance user satisfaction, retention, and overall success in metaverse applications. Additionally, the insignificant role of loading time suggests developers might focus more on content richness and interactive features rather than solely on reducing load times.

Practitioners, including educators and curriculum designers, should consider these factors when developing or selecting metaverse platforms for educational purposes. By focusing on enhancing the quality of presence and interactivity while minimizing cyber sickness, they can create more effective and satisfying learning environments for students.

These recommendations can guide the development of more effective and user-friendly educational technologies, ultimately enhancing learning experiences and outcomes in the increasingly popular digital learning spaces.

6.3 Limitation and future research directions

This study, while comprehensive, has limitations that pave the way for future research. The cross-sectional nature of the data limits our ability to draw conclusions about the causality of relationships between presence, interactivity, cyber sickness, loading time, and satisfaction. Longitudinal studies could provide deeper insights into how these factors impact satisfaction over time. Additionally, the study was confined to a single metaverse platform, which might limit the generalizability of the findings. Future research should explore these relationships across various platforms and with diverse user groups to validate and extend the applicability of the results, potentially exploring the role of demographic variables in moderating these effects. Moreover, this study did not incorporate variables such as information security, which is often emphasized in online platforms[35]. Future research should comprehensively include variables like information security and individual sensitivity to security to enhance the explanatory power of the model. Finally, the analysis being limited to a single metaverse platform may restrict the generalizability of the findings. Recognizing the potential variability across different platforms, future research should examine these dynamics within a broader range of virtual learning environments to ascertain the consistency of the observed effects.

References

[1] D. Woo, S. Lee, and S. Yu, "Comparative Study of User Interface using Virtual Reality Driving Simulation", Journal of KIIT, Vol. 22, No. 1, pp. 235-244, Jan. 2024. http://doi.org/10.14801/jkiit.2024.22.1.235.

[2] M. Choi and J. Kim, "Analysis of a Cognitive Training based on Virtual Reality Contents for the Elderly", Journal of KIIT, Vol. 18, No. 10, pp. 139-147, Oct. 2020. http://doi.org/10.14801/jkiit.2020.18.10.139.

[3] Y.-J. Lee, "Artificial Intelligence Immersion Enhancement Technology using Human Emotion Information and Body Information in the Coexistence Space of Virtual and Reality", Journal of KIIT, Vol. 20, No. 9, pp. 125-136, Sep. 2022. http://doi.org/10.14801/jkiit.2022.20.9.125.

[4] J. Bailenson, "Experience on demand: What virtual reality is, how it works, and what it can do", WW Norton & Company, Jan. 2018.

[5] M. Slater and S. Wilbur, "A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments", Presence: Teleoperators & Virtual Environments, Vol. 6, No. 6, pp. 603-616, Dec. 1997. http://dx.doi.org/10.1162/pres.1997.6.6.603.

[6] J.-H. Wu, R. D. Tennyson, and T.-L. Hsia, "A study of student satisfaction in a blended e-learning system environment", Computers & education, Vol. 55, No. 1, pp. 155-164, Aug. 2010. https://doi.org/10.1016/j.compedu.2009.12.012.

[7] J. J. LaViola, "A discussion of cybersickness in virtual environments", ACM Sigchi Bulletin, Vol. 32, No. 1, pp. 47-56, Jan. 2000. https://doi.org/10.1145/333329.333344.

[8] Q. Chen and Z. Yan, "Does multitasking with mobile phones affect learning? A review", Computers in Human behavior, Vol. 54, pp. 34-42, Jan. 2016. https://doi.org/10.1016/j.chb.2015.07.047.

[9] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology", MIS quarterly, Vol. 13, No. 3, pp. 319-340, Sep. 1989. http://dx.doi.org/10.2307/249008.

[10] R. L. Daft and R. H. Lengel, "Organizational information requirements, media richness and structural design", Management Science, Vol. 32, No. 5, pp. 554-571, May 1986. https://doi.org/10.1287/mnsc.32.5.554.

[11] K. Kim, "A study on the effect of VR contents characteristics on educational effects - Focusing on the perceived characteristics of VR content", Journal of Korea Service Management Society, Vol. 22, No. 3, pp. 369-390, Sep. 2021. http://doi.org/10.15706/jksms.2021.22.3.016.

[12] M. K. M. Nasir, "The influence of social presence on students' satisfaction toward online course", Open Praxis, Vol. 12, No. 4, pp. 485-493, Dec. 2020. https://doi.org/10.5944/openpraxis.12.4.1141.

[13] M. G. Salimon, S. M. M. Sanuri, O. A. Aliyu, S. Perumal, and M. M. Yusr, "E-learning satisfaction and retention: A concurrent perspective of cognitive absorption, perceived social presence and technology acceptance model", Journal of Systems and Information Technology, Vol. 23, No. 1, pp. 109-129, Mar. 2021. http://doi.org/10.1108/JSIT-02-2020-0029.

[14] C. L. Huang, Y. F. Luo, S. C. Yang, C. M. Lu, and A.-S. Chen, "Influence of students' learning style, sense of presence, and cognitive load on learning outcomes in an immersive virtual reality learning environment", Journal of Educational Computing Research, Vol. 58, No. 3, pp. 596-615, Aug. 2020. http://doi.org/10.1177/0735633119867422.

[15] S. T. Bulu, "Place presence, social presence, co-presence, and satisfaction in virtual worlds", Computers & Education, Vol. 58, No. 1, pp. 154-161, Jan. 2012. http://doi.org/10.1016/j.compedu.2011.08.024.

[16] M. G. Violante and E. Vezzetti, "Virtual interactive e?learning application: An evaluation of the student satisfaction", Computer Applications in Engineering Education, Vol. 23, No. 1, pp. 72-91, Aug. 2015. http://doi.org/10.1002/cae.21580.

[17] Y.-M. Cheng, "Students' satisfaction and continuance intention of the cloud-based e-learning system: roles of interactivity and course quality factors", Education+ Training, Vol. 62, No. 9, pp. 1037-1059, Sep. 2020. http://doi.org/10.1108/ET-10-2019-0245.

[18] H. Q. Yousaf, S. Rehman, M. Ahmed, and S. Munawar, "Investigating students' satisfaction in online learning: the role of students' interaction and engagement in universities", Interactive Learning Environments, Vol. 31, No. 10, pp. 7104-7121, Apr. 2023. http://dx.doi.org/10.1080/10494820.2022.2061009.

[19] H.-J. Jang and K.-H. Kim, "Study on the Influence of VR Characteristics on User Satisfaction and Intention to Use Continuously -Focusing on VR Presence, User Characteristics, and VR Sickness-", The Journal of the Korea Contents Association, Vol. 18, No. 5, pp. 420-431, May 2018. http://doi.org/10.5392/JKCA.2018.18.05.420.

[20] J. Kim, "A study on the characteristics of VR content to reduce cyber sickness", Journal of Digital Art Engineering and Multimedia, Vol. 9, No. 2, pp. 149-158, Jun. 2022. http://doi.org/10.29056/jdaem.2022.06.04.

[21] M. Mousavi, Y. H. Jen, and S. N. B. Musa, "A review on cybersickness and usability in virtual environments", Advanced Engineering Forum, Vol. 10, pp. 34-39, Dec. 2013. http://doi.org/10.4028/www.scientific.net/AEF.10.34.

[22] S. Mareta, J. M. Thenara, R. Rivero, and M. Tan-Mullins, "A study of the virtual reality cybersickness impacts and improvement strategy towards the overall undergraduate students' virtual learning experience", Interactive Technology and Smart Education, Vol. 19, No. 4, pp. 460-481, May 2022. http://doi.org/10.1108/ITSE-10-2021-0193.

[23] A. N. R. Chandra, F. E. Jamiy, and H. Reza, "A systematic survey on cybersickness in virtual environments", Computers, Vol. 11, No. 4, Mar. 2022. http://doi.org/10.3390/computers11040051.

[24] H. Kim, H. Song, and S. Park, "Proper response times and design factors influencing user satisfaction with diverse touch tap operations for

the smartphone", Archives of Design Research, Vol. 27, No. 2, pp. 95-105, May 2014. http://doi.org/10.15187/adr.2014.05.110.2.95.

[25] D. Heidrich, A. Wohlan, and M. Schaller. "Perceived Speed, Frustration and Enjoyment of Interactive and Passive Loading Scenarios in Virtual Reality", Cham: Springer International Publishing, Vol. 12428, Oct. 2020. http://doi.org/10.1007/978-3-030-59990-4_26.

[26] M. Yu, R. Zhou, Z. Cai, C.-W. Tan, and H. Wang, "Unravelling the relationship between response time and user experience in mobile applications", Internet Research, Vol. 30, No. 5, pp. 1353-1382, May 2020. http://doi.org/10.1108/INTR-05-2019-0223.

[27] W.-S. Chang, "The Effects of TBL (Team based learning) on the academic achievements and learning satisfaction of University students", The Journal of the Korea Contents Association, Vol. 16, No. 12, pp. 655-666, Dec. 2016. http://doi.org/10.5392/JKCA.2016.16.12.655.

[28] C.-S. Kim, S.-H. Lee, and E.-H. Oh, "The impact of interaction factors of digital contents on flow and use intention", The Journal of the Korea Contents Association, Vol. 11, No. 9, pp. 212-224, Sep. 2011. http://doi.org/10.5392/JKCA.2011.11.9.212.

[29] E. J. Wolf, K. M. Harrington, S. L. Clark, and M. W. Miller, "Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety", Educational and psychological measurement, Vol. 73, No. 6, pp. 913-934, Oct. 2013. https://doi.org/10.1177/0013164413495237.

[30] J. Henseler, et al., "Common beliefs and reality about PLS: Comments on Ronkko and Evermann (2013)", Organizational Research Methods, Vol. 17, No. 2, pp. 182-209, Apr. 2014. https://doi.org/10.1177/1094428114526928.

[31] M. Sarstedt and J.-H. Cheah, "Partial least squares structural equation modeling using SmartPLS: a software review", Journal of Marketing Analytics, Vol. 7, No. 3, pp. 196-202, Jun. 2019. http://doi.org/10.1057/s41270-019-00058-3.

[32] J. C. Nunnally, "Psychometric theory (2nd ed.)", New York: Mcgraw Hill Book Company, 1978.

[33] J. Hair, C. L. Hollingsworth, A. B. Randolph, and A. Y. L. Chong, "An updated and expanded assessment of PLS-SEM in information systems research", Industrial Management & Data Systems, Vol. 117, No. 3, pp. 442-458, Apr. 2017. http://doi.org/10.1108/IMDS-04-2016-0130.

[34] C. Fornell and D. F. Larcker, "Evaluating structural equation models with unobservable variables and measurement Error", Journal of Marketing Research, Vol. 18, No. 1, pp. 39-50, Feb. 1981. http://doi.org/10.1177/002224378101800104.

[35] D. H. Shin, "Enhancing User Experience in Information Security E-Recruiting Platforms", Journal of KIIT, Vol. 22, No. 9, pp. 185-196, Sep. 2024. http://dx.doi.org/10.14801/jkiit.2024.22.9.185.

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