

AN ANALYSIS OF INFORMATION AND COMMUNICATION TECHNOLOGY AND VIRTUAL REALITY TECHNOLOGY IMPLEMENTATION THROUGH A QUANTITATIVE RESEARCH ON USERS' EXPERIENCES

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ABSTRACT

This study investigated users' overall experiences with <Klimt Inside> and <Stoclet Frieze>, based on the Technology Acceptance Model (TAM), using the convergence and integrated approach. In terms of <Klimt Inside>, the degree of satisfaction correlated with degree of immersion and Behavioral Intention to Digital Exhibition. The degree of satisfaction and degree of immersion correlated with the detail factors of usability for learning and usability for appreciation. All detail factors of perceived ease of use positively correlated with the degree of satisfaction and degree of immersion. With regard to <Stoclet Frieze>, the degree of satisfaction with the VR application significantly correlated with the degree of immersion and Behavioral Intention to Digital Exhibition. However, the degree of satisfaction with the VR application did not affect the degree of satisfaction and degree of immersion with <Klimt Inside>. In the case of <Stoclet Frieze>, the detail factors of usability for learning and usability for appreciation were relevant to the degree of satisfaction and degree of immersion. The degree of satisfaction with the VR application significantly correlated with the degree of immersion and Behavioral Intention to the VR Application. The detail factors of perceived ease of use significantly correlated with the degree of satisfaction and influenced the degree of immersion with the VR application. Finally, both <Klimt Inside> and <Stoclet Frieze> did not guarantee the same quality of the original regarding usability for appreciation. Most importantly, these technological reproductions never fully substituted the originals, but their benefits are noteworthy as a means for stimulating intrinsic motivation in learning. As more museums are exploring ICT and VR technology in their exhibition environments, museum professionals and technology specialists should collaborate well to achieve optimal results. Insight on the visitor experience through in-depth and on-going research on the adoption of technologies is required to enrich visitor engagement.

Keywords: *Information and Communication Technology, Digital Exhibition, Virtual Reality Application, User Experience, Technology Acceptance Model (TAM)*

1. INTRODUCTION

The proliferation of information and communication technology (ICT) is transforming all aspects of museum operations while enhancing the traditional functions [1]. Digitization represents the new world order, that is, the transition from simulacra to simulation; from copying to modeling [2]. With the emergence of the information age, digital exhibition has become an inexorable trend for museum technical applications [3]. The museum exhibition environments and the visitors' experience have also grown beyond expectations with the emergence of increasingly affordable media and technologies. In addition to physical

exhibits, museums have also integrated copious resources of their collections with new technologies in order to create new values.

The change brought by the new media technology is twofold. On the one hand, digitized images of artworks introduced a new era for representation and new media technologies applied to digital reproductions that attract the visitors to be immersed in digitally remediating environments. On the other hand, many museums have built virtual museums or virtual tours on their websites in the last decade. Museums based on virtual reality (VR) technology allow users to explore at their own pace, examining high-resolution versions of authentic works of art through the lenses of VR headsets.

With the advent of ICT, virtual reality technology and new media technologies for generating, distributing, and presenting images, museums have transformed tangible artworks into intangible ones. These technologies are designed to increase access to cultural experience and knowledge, to enrich visitor engagement, and to inspire new ways of sharing cultural stories by heightening multisensory engagement and forging deeper cognitive and emotional contextual connections with artifacts and objects [4] [5]. As digital exhibitions and VR applications spread rapidly in the exhibition environment, examining the implementation and acceptance of digital and virtual reproductions from the users' perspective is growing in importance.

2. RELATED WORKS

2.1 The Emergence of Digital Exhibition

Computers are transforming traditional art forms and allowing new kinds of art forms to be developed. As a means of production and reproduction, for example, computers enable museums to create digital images and sounds, to build interactive installations, to design multimedia websites, or to program self-evolving art forms. Because the computer is primarily a machine for processing information and not a machine for making objects, it provides a malleable medium that provides the artist with a large variety of tools for manipulating data [6]. In addition, there are a number of technological inventions that have allowed the production of mechanical copies from an original, which are indistinguishable from the original in as many ways as possible.

Digitization represents the new world order, that is, the transition from simulacra to simulation; from copying to modeling [7]. In the process of digital and/or virtual reproduction, the data elements can be constantly combined, decombined and recombined with a fundamental ontological change, and can eventually generate a visual image as a complete simulation. Thus, in the age of digital reproduction, everything becomes an object for recombination and manipulation [8]. Through the recombination and manipulation process of data, digitized images of paintings are recognized as a completely new paradigm for representation in a museum context.



Figure 1. Image of the Grand Exhibition's Da Vinci Alive Exhibition Gallery

(Source: <http://grandeexhibitions.com/da-vinci-alive/>)

By leveraging data from digital archives, a digital exhibition has attracted viewers with its interactive and immersive features. This form of exhibition takes advantage of the usability of media technologies to increase the participation of visitors within an interactive knowledge setting and, consequently, provides a contemplation of masterpieces [9]. Since the modes of visitors' appreciation of exhibitions include contemplation, comprehension, discovery, and interaction, the design of the digital exhibition is also expected to go beyond just delivering monotonic images to viewers.

2.2 Virtual Reality (VR) in Museum Practices

The inclusion of VR in museum settings began in the mid-1990s, although there is no milestone date of adopting VR in the museum environment. In museum practices, VR varies from the Cave Automatic Virtual Environment (CAVE) systems to simple multimedia presentations and software applications. Virtual reality involves creating the experience and places participants in an environment that is not experienced normally or easily. Of particular interest to museums in the use of VR is the fact that visitors can travel through space and time without stepping out of the museum building [10]. Virtual reality technology can help museums overcome a number of limitations. For example, it can help with displays of exhibits that a museum cannot present, either because of lack of space or fragility and their need for special handling and it can help when there is a need for visualizing and simulating an environment, construction, or object that no longer exists, which are partially preserved or cannot be visited easily. Museum visitors are attracted to VR technology for various reasons, including the captivating sense of immersion given by the surround vision, filling an entire field of view; simulation of stereoscopic viewing; a viewer-centered perspective when

perspective depends on one's position; real-time performance and interaction when what is seen is generated and responsive to viewers' actions; and the involvement of all senses [11].

In the field of conservation and restoration, VR constitutes a means to reconstruct artworks or artistic and historical environments that time has destroyed or damaged, so as to preserve and safeguard them, or it can be used as an assistance tool for restoration, and even to perform virtual restoration on damaged areas of artworks without damaging the original specimens. Unlike cultural heritage areas, traditional museums are less inclined to employing VR technology. Despite general consent on its necessity and affordability, the development of a virtual environment presents a number of challenges to museums. For example, acquiring and maintaining equipment can be very expensive; devices are often experimental and sometimes too fragile to be used within museum spaces; some visitors suffer from VR simulator sickness [12].

In the last decade, some museums, which have been actively involved in accepting technologies, began to offer virtual museums or virtual tours. However, these virtual museums can hardly be defined as true VR due to the lack of both interaction and immersive features. With the advent of 3D computing and commercialization of head-mounted displays (HMDs) such as the Oculus Rift and Samsung Gear on a large scale, more sophisticated VR experiences are currently available to the public. For example, the Dutch design agency, Archivision, has developed a 3D model of a small fictional museum under the commission of Europeana; it is called EUseum, and users can marvel at masterpieces from the Dutch Rijksmuseum [13]. This VR museum allows users to explore at their own pace, examining high-resolution versions of real works of art through the lenses of VR headsets.

By 2015, museums began opening their doors to VR applications with headsets. The British Museum has recently achieved a virtual recreation of a Bronze Age roundhouse utilizing Samsung Gear VR headsets [14]. The Natural History Museum in London also brings ancient museum specimens to life, with the help of David Attenborough [15]. At the same time, VR applications of Van Gogh's artworks have been produced by several companies specializing in designing and creating virtual presentations such as

Borrowed Light Studios, Oniriden, and so on since the first half of 2014.

With the development and wide diffusion of VR technology, I have encountered a new type of online museum service. For example, Google Arts and Culture has provided "Museums Views" for virtual tours of the world's greatest museums and heritage sites [16]. The Kremer Museum, developed in 2017, is the foremost museum to exist entirely within the virtual realm. It is an innovative new museum concept that combines the latest VR technology with the 17th Century Dutch and Flemish old master paintings. For creating the Kremer, each painting has been photographed between 2,500 and 3,500 times using the "photogrammetry" technique to build one ultra-high resolution visual model for each painting, allowing the museum's visitors to enjoy a deeply immersive experience with the paintings [17]. Using VR technology, visitors are able to examine the artworks' surface and colors up-close and view the reverse of the paintings to explore each work's unique stamps of provenance. In addition, the sense of immersion is being explored, especially for the ability to encourage participants' active engagement, evoke senses, and fully capture users' attention.



Figure 2. Image of the Kremer Collection

(Source: <http://www.klimt.com/en/gallery/stoclet-frieze/klimt-stocletfries-real.ihtml>)

3. PROBLEM STATEMENT

Generally, digital exhibitions and VR applications can be characterized as "digital reflections" and "virtual reflections" of physical entities that do not exist *per se*, but which act complementarily to become an extension of artworks in the walled museums [18]. Both digital and virtual reproductions are inherently different from the tangible artworks, and they may add to or

change the quality of the original. To be more specific, when a work of art is transformed into a digital and/or virtual reproduction, the most important requirement for technologies is that they should cognitively and emotionally support visitors to mediate and engage with the aura and authenticity of the original artwork. Particularly, to virtualize an artwork means to actualize it digitally; to simulate it using computer graphics technology.

In this situation, both digital media and VR applications can usurp the quality of real artworks. Moreover, these reproductions can intrude on the authentic ambience in art museums. As they act as a surrogate for authentic objects, these developments raise new questions concerning the quality of experience and meanings in a virtual environment as well as in a museum environment. Although ICT and VR technology have penetrated the field of museums and exhibitions, little research has systematically focused on how viewers respond to this infusion.

This study investigated users' overall experiences with *<Klimt Inside>* and *<Stoclet Frieze>*. The former is a digital exhibition, while the latter is a VR application used in the digital exhibition. The *<Klimt Inside>* exhibition was held in Seoul from December 8, 2016 to March 3, 2017 (see Figure 1). This exhibition was designed by Media & Art, which has been successful with *<Van Gogh Inside (2016)>* and new media exhibitions. Unlike the traditional methods of viewing renowned paintings hung on museum walls, this digital exhibition not only allows visitors to experience the works of art complemented by lighting and (light-emitting diode) LED screens but also offers visitors an immersive, walk-through experience of the painter's works. In this exhibition, projection mapping was applied to project high-resolution images on the walls and floors of each section with the motion graphics and sound effects so that the original artworks were effectively reproduced in the digitally-remediated environment. The adaptation or mapping of images generates an optical illusion that transforms the fusion between the projected image and the real surface into a new object that appears real [19].

Divided into six exhibition zonings (End of Century, Ver Sacrum, Women, Stoclet Frieze, Later Colors, and Kiss), each zoning offers unique insight into the Austrian symbolist painter. Virtual reality interactive zone of a Stoclet Palace dining room outside of the main exhibition is decorated

with an artwork which Klimt was commissioned to create (see Figure 2). The Stoclet Palace is a private mansion built by architect Josef Hoffmann between 1905 and 1911 in Brussels, Belgium, for a banker and an art lover named Adolphe Stoclet. Considered Hoffman's masterpiece, Stoclet's house is one of the most refined and luxurious private houses of the twentieth century. The mansion is still occupied by the Stoclet family and is not open to visitors. It was designated as a world heritage site by UNESCO in June 2009 [20]. *<Stoclet Frieze>* enables immersion through a 360-degree perspective and 3D imagery as well as real-time interactions and multisensory experiences based on the users' location and responses to their behaviors.

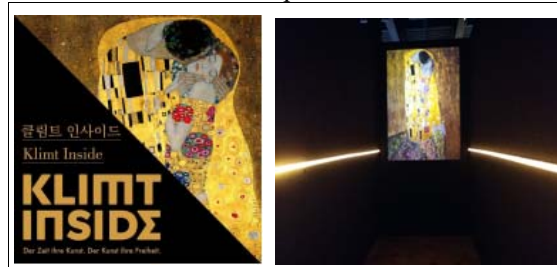


Figure 3. *Klimt Inside* Exhibition Poster and the Image of *Kiss Zoning* in *<Klimt Inside>*



Figure 4. Image of *<Stoclet Frieze>* (the original artwork) and the Screenshot Image of the VR Application

In this paper, the primary concerns raised by the author were on how users perceive the values and qualities embedded in both digital and virtual reproductions. I claim that aura can migrate from an original to these technological reproductions, based on Bruno Latour and Adam Lowe's argument [21]. In light of this, I hypothesized that there are conditions under which a digital and/or a virtual reproduction of Gustav Klimt's artworks can generate an authentic experience that is as aesthetically valuable as the experience with the original for users.

4. RESEARCH MODEL

I designed a survey using the Technology

Acceptance Model (TAM) which is an information systems theory advocated by Bagozzi and Warshaw in 1986 [22]. The Technology Acceptance Model is widely accepted as a framework to understand users' IT acceptance processes. It has proven to be an appropriate model that explains much of the variance in users' behavioral intention related to IT adoption and usage across a wide variety of contexts. In particular, the adaptation of TAM to the exhibition environment has gained an increasing significance lately, and TAM has been proved as an evaluation model for examining the values and qualities of digital museums and digital exhibitions. Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are key variables in TAM, and they affect viewing experiences as found in previous studies on digital remediation [23] [24] [25]. However, there are still only a few studies that have focused on the application and evaluation of new media technology in museum exhibition contexts.

In this paper, PU and PEOU are operationally defined and their correlations between the degree of satisfaction (DOS), the degree of immersion (DOI) and the degree of fatigue (DOF) are explained (Figure 5). Perceived Usefulness is measured with the variables of Usability for Learning (UFL) and Usability for Appreciation (UFA) with factors (Table 1). On the other hand, the influence of three factors, namely, the Storytelling Factor (SF), the Technical Factor (TF), and the Environmental Factor (EF) on PEOU (Table 2-1), are analyzed in the case of the PEOU of <Klimt Inside>. The same factors were used to measure the PU of <Klimt Inside> and <Stoclet Friese> in this study. However, in the case of the evaluation of PEOU in <Stoclet Friese>, informativeness, efficiency in navigation and orientation, user control, visibility, interaction, presence, and sound effect were used as factors [26] [27] [28] (Table 2-2).

Table 1: Operational Definitions of PU and Detail Factors for <Klimt Inside> and <Stoclet Friese>

Factors	Detail Factors
UFL	Understanding the artworks and artists
	Arousal of curiosity and searching for information
	Fertilizing conversation with companions
	Suitability for learning
UFA	Artistic value and properties to the originals
	Authenticity and aura to the originals
	Interactivity and immersiveness to the originals
	Suitability for appreciation

Table 2-1: Operational Definitions of PEOU and Detail Factors for <Klimt Inside>

Factor	Detail Factors
SF	New interpretations and approaches to the originals
	Thematic exhibition circulation
	Dynamic elements through motion graphics
	Visibility and readability of interpretive materials
TF	Interactivity
	Motion graphic effects
	High-resolution images
	Sound effects
EF	Big-sized screen
	Curved screen
	Background music
	Optimal exhibition environment

Table 2-2: Operational Definitions of PEOU and Detail Factors for <Stoclet Friese>

Detail Factors of PEOU
Informativeness
Efficiency in navigation and orientation
User control
Visibility
Interaction
Presence
Sound effect

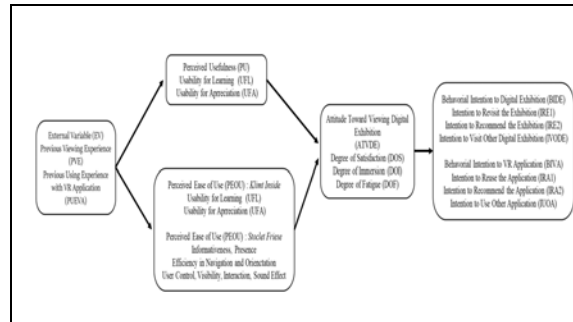


Figure 5. Research Model

In this research, by using specific applications of technology, participants will enhance UFL and UFA performance within context (PU) and also increase their ability to experiment with new innovation and evaluate its benefits easily within SF, TF, and EF (PEOU). The PU and PEOU will influence ATVDE and ATVDE will form a positive behavioral intention to BIDE (IRE1, IRE2, IVODE). Based on the research model (Figure 5), I set up thirteen hypotheses to examine the overall evaluation of the participants' experiences in the digitally and virtually remediated environment (Table 3). In order to shed light on the participants' acceptance of technologies used in <Klimt Inside> and <Stoclet Friese>, I focus on the relationship between PU and DOS and DOI as well as the relationship between PEOU and DOS and DOI.

Table 3: Hypotheses

subject	No.	Hypotheses
<Klimt Inside>	H1	DOS has a correlation with DOI
	H2	DOS has a correlation with BIDE
	H3	PVE has a correlation with UFL
	H4	PVE has a correlation with UFA
	H5	PU has a correlation with DOS
	H6	PU has a correlation with DOI
	H7	PEOU has a correlation with DOS
	H8	PEOU has a correlation with DOI
<Stoclet Frieze>	H1	DOS has a correlation with DOI
	H2	DOS has a correlation with BIVA
	H3	DOS in <Stoclet Frieze> has a correlation with DOS <Klimt Inside>
	H4	PU has a correlation with DOS
	H5	PEOU has a correlation with DOS

5. RESEARCH METHODOLOGY

To examine the users' overall experiences with <Klimt Inside> and <Stoclet Frieze>, I conducted a survey in May 2017. The questionnaire, consisting of 38 questions on a Likert scale from 1 to 5 (where 1 = not agree and 5 = strongly agree), was designed to verify the hypotheses. Following data collection, the quantitative data were analyzed using Frequency Analysis, Correlation Analysis, and one-way ANOVA in SPSS 12.0.1 (Table 3). I collected a population of university students who are categorized as the digitally native and tech-savvy generation (n=50). This population showed the highest returns and the highest response rates in the previous study [29].

Table 4: Components of the Questionnaire

	Components	No. of questions
<Klimt Inside>	Previous Viewing Experience (PVE)	2
	Perceived Usefulness (PU) & Perceived Ease of Use (PEOU)	8
	Attitude Toward Viewing Digital Exhibition (ATVDE)	6
	Behavioral Intention to Digital Exhibition (BIDE)	4
<Stoclet Frieze>	Previous Using Experience (PUE)	1
	Perceived Usefulness (PU) & Perceived Ease of Use (PEOU)	7
	Attitude Toward Using VR Application (ATUVA)	6
	Behavioral Intention to VR Application (BIVA)	4

6. FINDINGS

6.1 The Evaluation of <Klimt Inside>

According to the results of the frequency analysis, it was determined that survey participants'

previous experiences (PVE) varied in terms of the frequency of museum visiting (Figure 6). The population was rich in knowledge of art and technology. At the same time, this university student group had the characteristics of a digital native. The majority of participants (81.4%) had plenty of previous visiting experiences (PVE) in digital exhibitions and new media exhibitions including <Van Gogh Inside (2016)>, <Monet's Impression Exhibition (2016)>, <Hello Michelangelo (2017)>, and <Alice in the Rabbit Hall (2017)>. The museum visiting frequency of the participants did not have any correlation with DOS, DOI, and DOF. However, according to the result of the mean value analysis, having higher visiting frequency means lower DOS and DOI, and higher DOF (Table 5).

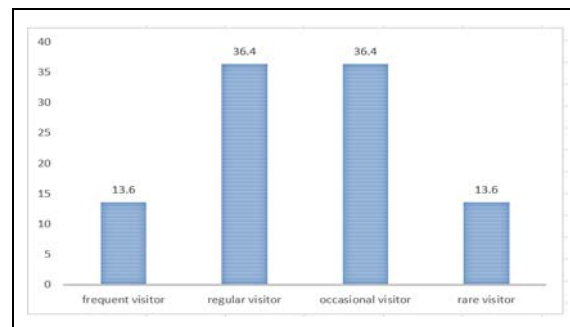


Figure 6: Participants' Frequency of Museum Visiting (%)

Table 5: Comparison of Mean Value of DOS, DOI, and DOF in terms of Frequency of Visiting

Frequency of Museum Visiting	DOS	DOI	DOF
frequent	2.56	2.44	3.27
regular	2.83	2.83	3.00
occasional	2.88	3.06	2.64
rare	3.00	3.17	2.59

The properties of <Klimt Inside> were defined as "entertainment" rather than "aesthetic" or "educational" due to quality discrepancy from the traditional art exhibition (Figure 7). The entertainment attribute of the VR application was rated higher than that of the digital exhibition. The viewing time of <Klimt Inside> was longer than the average time spent on viewing the traditional exhibition, ranging on average between 25.7 and 41.0 seconds per media (Figure 8).

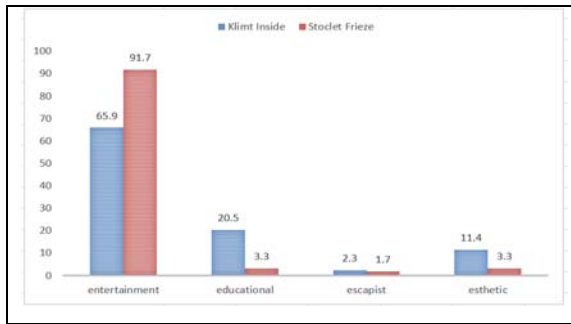


Figure 7: Property of <Klimt Inside> and <Stoclet Frieze> (%)

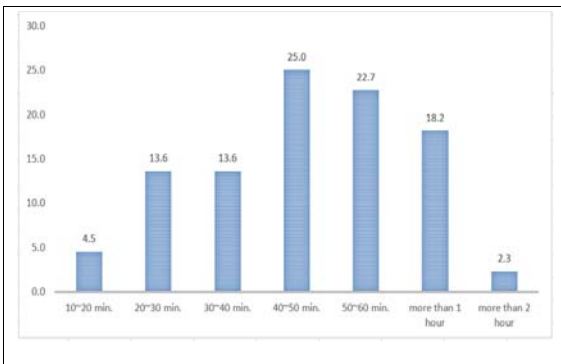


Figure 8: Ratio of Viewing Time (%)

In order to verify the correlation between PVE and UFL and the correlation between the PVE and UFA, I implemented standard derivation. The PVE of the original artworks of Klimt had no correlation with UFL, on the other hand, these experiences had negative correlations with the detail factors of UFA (Table 6). According to the result of the mean value analysis, Group A, which had previous viewing experience had a lower mean value compared to that of Group B, which had no previous experience. In particular, there was a deviation between Group A and Group B in terms of the mean values of the detail factors of UFA. Group A gave lower scores on the detail factors of UFA than Group B due to the lack of aura and authenticity embedded in the traditional art exhibition (Table 7). In addition, the mean value of the suitability for learning was higher than that of the suitability for appreciation. This means that previous experience with the original artworks has much influence on the suitability for learning rather than the suitability for appreciation.

Table 6: Correlation between Detail Factors of UFA and Previous Viewing Experience (PVE) of the Original Artworks of Klimt (* $p < .05$)

Usability for Appreciation (UFA)	Correlation Coefficient
Artistic value and properties to the originals	-3.48*
Authenticity and aura to the originals	-3.13*
Interactivity and immersiveness to the originals	-3.26*
Suitability for appreciation	-3.18*

Table 7: Comparison of Mean Value of Detail Factors of UFL and Detail Factors of UFA to the Previous Viewing Experience (PVE)

Factors	Detail factors	Group A Mean Value	Group B Mean Value
UFL Group A/B Average of Mean Value 3.15/ 3.35	Understanding the artworks and the artists	2.7	3.35
	Arousal of curiosity and searching for information	3.3	3.41
	Fertilizing conversation with companions	3.15	3.30
	The suitability for learning	3.2	3.25
UFA Group A/B Average of Mean Value 2.8/3.12	Artistic value and properties to the originals	1.6	2.59
	Authenticity and aura to the originals	1.7	2.56
	Interactivity and immersiveness to the originals	2.23	2.68
	Suitability for appreciation	2.8	3.12

6.1.1 PU and their correlation with DOS and DOI

The ratios of UFL factors were higher than those of UFA factors (Table 8). I also explored the relevance between pictorial sameness and aesthetic sameness by comparing the ratios of SFL and SFA. Survey participants rated the suitability for learning as high as twice the suitability for appreciation. The detail factors of UFL were significantly correlated with the SFL ($p < .01$), and three factors of UFA have correlations with the SFA ($p < .01$) (Table 9). In addition, three factors in both UFL and UFA in PU were correlated with DOS and DOI (Table 10).

Table 8: Ratio Comparison of Detail Factors of UFL and UFA (%)

Factors	Detail factors	Ratio
UFL	Understanding the artworks and the artists	47.7
	Arousal of curiosity and searching for information	47.8
	Fertilizing conversation with companions	43.1

	Suitability for learning	43.2
UFA	Artistic value and properties to the originals	18.1
	Authenticity and aura to the originals	15.9
	Interactivity and immersiveness to the originals	26.8
	Suitability for appreciation	20.4

Table 9: Correlation between Detail Factors of UFL and the Suitability for Learning (SFL), and Correlation between Detail Factors of UFA and the Suitability for Appreciation (SFA) (** $p < .01$)

Factors	Detail factors	Correlation Coefficient
UFL	Understanding the artworks and the artists	.417**
	Arousal of curiosity and searching for information	.531**
	Fertilizing conversation with companions	.415**
UFA	Artistic value and properties to the originals	.364**
	Authenticity and aura to the originals	.411**
	Interactivity and immersiveness to the originals	.442**

Table 10: Correlation between Detail Factors of UFL and DOS and DOI, and Correlation between Detail Factors of UFA and DOS and DOI (** $p < .01$, * $p < .05$)

Factors	Detail factors	DOS Correlation Coefficient	DOI Correlation Coefficient
UFL	Understanding the artworks and the artists	.527**	.435**
	Arousal of curiosity and searching for information	.398**	.433**
	Fertilizing conversation with companions	.312**	.465**
	The suitability for learning	.376**	.429**
UFA	Artistic value and properties to the originals	.417**	.315**
	Authenticity and aura to the originals	.562**	.422**
	Interactivity and immersiveness to the originals	.318**	.428**
	The suitability for appreciation	.387**	.404**

Overall, the DOS (25.0%) and the DOI (29.5%) turned out to be relatively low, compared to other digital exhibitions in previous research (Table 11). In fact, almost half of survey participants (42.3%) emphasized that *<Klimt Inside>* was less immersive than other digital exhibitions. In particular, 29.5% of the participants had no sense of immersion in the digitally remediated environment. The frequency of visit did not affect DOS and DOI in terms of correlation.

Interestingly, the higher the frequency of visit, the lower the degree of satisfaction and the degree of immersion based on the mean value data (Table 12). The data show that the DOS not only had a significant correlation with the DOI (.336, $p < .01$), but also had an influence on the BIDE (IRE1, IRE2, and IVODE) (Table 13).

Table 11: Ratio of DOS, DOI, IRE1, IRE2, and IVODE (%)

Detail Factors of ATVDE and BIDE	Ratio
DOS	25.0
DOI	29.5
DOF	43.1
IRE1	20.5
IRE2	25.0
IVODE	45.5

Table 12: Comparison of Mean Value of DOS and DOI in terms of Frequency of Museum Visiting

Frequency of Museum Visiting	DOS	DOI
Frequent visitor	2.56	2.44
Regular visitor	2.83	2.83
Occasional visitor	2.88	3.06
Rare visitor	3.00	3.17

Table 13: Correlation between DOS and DOI, IRE1, IRE2, and IVODE (** $p < .01$)

Detail Factors	Correlation Coefficient
DOI	.336**
IRE1	.422**
IRE2	.308**
IVODE	.372**

6.1.2 PEOU: The correlation between the detail factors of PEOU and DOS and the correlation between the detail factors of PEOU and DOI

I measured the impact of the storytelling factor (SF), the technical factor (TF), and the environment factor (EF) and analyzed the correlations between these factors and DOS and DOI. According to the results of the frequency analyses, the influence of EF was commonly higher than the other two factors in both DOS and DOI (Figure 9). In terms of EF, the elements that heavily attracted the viewers were the optimal exhibition environment and the background music. TF was highly valued compared to SF and sound effects were the key factor that impacted on DOS and DOI (Table 14). According to the correlation data, all

detail factors of PEOU correlated with DOS and DOI. The detail factors of TF and EF had significant correlations ($p < .01$) (Table 15).

Table 14: Ratio of Detail Factors of PEOU (%)

Detail Factors	DOS	DOI
SF 1: new interpretations and approaches to originals	23.0	29.5
SF 2: thematic exhibition circulation	29.5	34.1
SF 3: dynamic elements through motion graphics	34.1	22.8
SF 4: visibility and readability of interpretative materials	38.7	27.3
TF 1: interactivity	29.5	29.6
TF 2: motion graphic effects	31.8	27.3
TF 3: high resolution images	27.3	43.2
TF 4: sound effects	59.1	61.4
EF 1: big-sized screen	36.3	40.9
EF 2: curved screen	34.1	45.4
EF 3: background music	45.5	61.4
EF 4: optimal exhibition environment	59.1	56.8

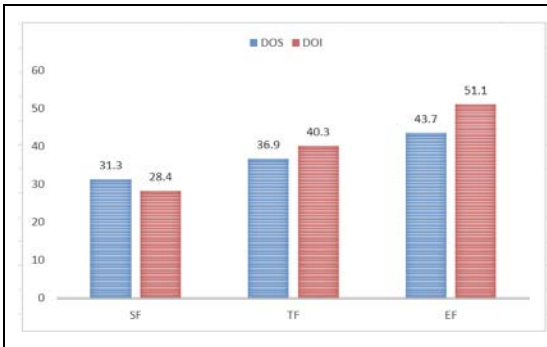


Figure 9: Comparison of Factors of PEOU in terms of DOS and DOI (%)

Table 15: Correlation between Detail Factors of PEOU and DOS, and Correlation between Detail Factors of PEOU and DOI (** $p < .01$, * $p < .05$)

Detail Factors	DOS Correlation Coefficient	DOI Correlation Coefficient
SF 1: new interpretations and approaches to originals	.518*	.453*
SF 2: thematic exhibition circulation	.392*	.485*
SF 3: dynamic elements through motion graphics	.348*	.412*
SF 4: visibility and readability of interpretative materials	.516*	.455*
TF 1: interactivity	.463**	.430**
TF 2: motion graphic effects	.334**	.412**
TF 3: high resolution images	.302**	.309**
TF 4: sound effects	.329**	.402**
EF 1: big-sized screen	.361**	.378**
EF 2: curved screen	.302**	.442**
EF 3: background music	.314**	.324**

EF 4: optimal exhibition environment	.335**	.515**
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According to the results from the frequency analysis, <Klimt Inside> did not receive positive feedback in terms of the immersiveness of exhibit media and in terms of the suitability for using new media technology (Table 16). The degree of fatigue (DOF) caused by viewing experience was highly evaluated compared to the degree of technological fatigue caused by new media technology, the degree of technological fatigue caused by the immersiveness of exhibit media, and the DOF caused by environmental factors. The degree of technological fatigue caused by new media technology, the degree of technological fatigue caused by the immersiveness of exhibit media and the degree of fatigue caused by the environmental factors did not have any correlations with DOS and DOI. Instead, the immersiveness of exhibit media and the suitability for using new media technology had a significant influence on DOS and DOI ($p < .01$) (Table 17).

Table 16: Ratio of Immersiveness of Exhibit Media, Suitability for Using New Media Technology, Degree of Technological Fatigue caused by New Media Technology, Degree of Technological Fatigue Caused by Immersiveness of Exhibit Media, Degree of Fatigue Caused by Environmental Factors and Degree of Fatigue Caused by Viewing Experience (%)

Factors	Ratio
Immersiveness of exhibit media	25.9
Suitability for using new media technology	35.8
Degree of technological fatigue caused by new media technology	29.5
Degree of technological fatigue caused by the immersiveness of exhibit media	23.6
Degree of fatigue caused by environmental factors	36.3
Degree of fatigue caused by viewing experience	43.1

Table 17: Correlation between Immersiveness of Exhibit Media and DOS and DOI, and Correlation between Suitability for Using New Media Technology and DOS and DOI (** $p < .01$)

Factors	DOS	DOI
Immersiveness of exhibit media	.312**	.326**
Suitability for using new media technology	.383**	.342**

6.2 The Evaluation of the VR Application <Stoclet Friese>

I asked the survey participants to use the VR application while they were viewing the exhibition (Figure 10). To begin the survey, the participants were simply asked to rate their

enjoyment of the usage of the VR application they had taken part in according to a four-point rating system, ranging from “Not good” to “Very good,” to which less than 30.0% of participants responded that the usage of the application was “Very good” or “Good.” Some participants, who enjoyed the usage of the VR application, pointed out that it was fun to walk around in the 3D environment. While other participants expressed that the total immersive experience with the headset was fantastic. These participants had no previous experience with using VR applications or VR headsets. In addition, participants who belonged to the lower museum visiting frequency groups such as the occasional visitor group and the rare visitor group were fascinated by the novelty of the content. When the experience was repeated and accumulated, they became interested in content and engaged in the multisensory experience in the virtual environment.

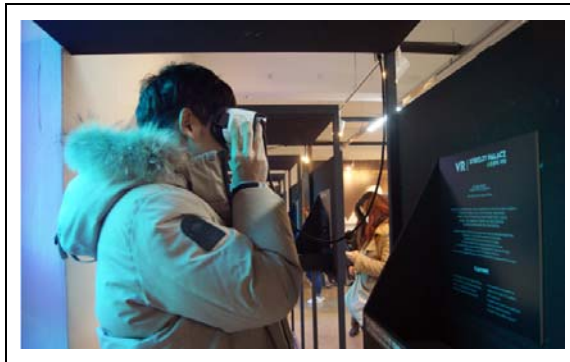


Figure 10: Image of a Participant Using the <Stoclet Frieze>

According to the result of the frequency analysis, the participants used the VR application for a very short time (1 min.~2 mins 30 seconds). The overall satisfaction with the VR application (23.0%) turned out to be lower than that of the digital exhibition (25.0%); on the other hand, the DOI (43.2%) was higher than that of the digital exhibition (29.5%) (Figure 11). The DOS of <Stoclet Frieze> was also lower than that of Van Gogh VR applications (50.0%) in a previous study. It had a correlation with the intention to rescue the application (.479, $p < .01$) and with the intention to recommend the application to others (.603, $p < .01$).

The DOS with the VR application had a significant correlation with the DOI with the VR application (.682, $p < .01$), IRA 1 (.610, $p < .01$), IRA 2 (.622, $p < .01$) and IUOA (.592, $p < .01$).

The DOS with the VR application did not affect the DOS with <Klimt Inside> and the DOI of the exhibition. Half of the survey participants (n=25) had previous experiences with using VR applications and less than half of them (n=10) were satisfied with using VR applications. Previous experiences with VR applications negatively affected the DOS ($r=-.343$, $p < .05$), however, they did not have any significant correlation with DOI ($r=.094$). In addition, the differences in the museum visiting frequency affected the DOS and less frequent visitors showed higher satisfaction (Table 18). Even though 54.2% of the participants felt technological fatigue and sickness while using VR applications, there was no correlation between technological fatigue and the DOS ($r=.221$).

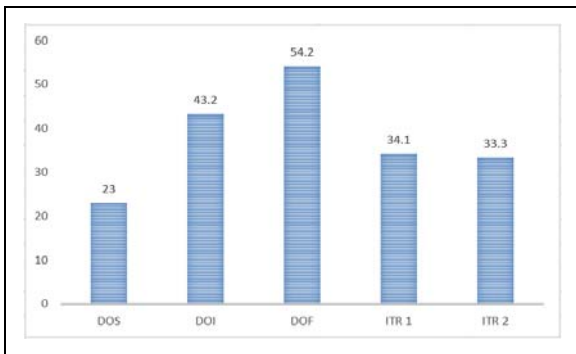


Figure 11: Ratio of Attitude Toward Using VR Application (ATUVA) and Behavioral Intention to VR Application (BIVA) (%)

Table 18: Ratio of Satisfaction in terms of Museum Visiting Frequency (%)

Frequency of Museum Visiting	Ratio of Satisfaction
Frequent visitor	16.8
Regular visitor	20.4
Occasional visitor	24.8
Rare visitor	29.7

According to the results of frequency analysis, the ratios of the detailed factors of UFL was higher than those of UFA, just as in the case of the evaluation of the digital exhibition (Table 19). The SFL (29.2%) also turned out to be higher than the SFA (12.3%). I also examined the correlation between UFL and DOS and DOI, and the correlation between UFA and DOS and DOI. Based on the results of correlation analysis, the detail factors of UFL and UFA were relevant to DOS and DOI (Table 20).

Table. 19: Ratio of Detail Factors of UFL and Detail Factors of UFA (%)

Factors	Detail factors	Ratio (%)
UFL	Understanding the artworks and the artists	36.2
	Arousal of curiosity and searching for information	33.0
	Fertilizing conversation with companions	26.4
	Suitability for learning	29.2
UFA	Artistic value and properties to the original	14.5
	Authenticity and aura to the original	15.7
	Interactivity and immersiveness to the original	29.8
	Suitability for appreciation	12.3

Table. 20: Correlation between Detail Factors of UFL and DOS and DOI, and Correlation between Detail Factors of UFA and DOS and DOI (** $p < .01$, * $p < .05$)

Factors	Detail factors	DOS Correlation Coefficient	DOI Correlation Coefficient
UFL	Understanding the artworks and the artists	.345**	.359**
	Arousal of curiosity and searching for information	.399**	.370**
	Fertilizing conversation with companions	.497**	.510**
	Suitability for learning	.731**	.311**
UFA	Artistic value and properties to the original	.686**	.685**
	Authenticity and aura of the original	.637**	.828**
	Interactivity and immersiveness to the original	.686**	.787**
	Suitability for appreciation	.682**	.389**

In terms of PEOU, nearly half of the participants experienced presence (47.7%) in the virtual environment. Perception of the presence, which is defined as the sense of “being there” in a mediated environment, depended, to some extent, on the quality of the VR application. This fact was confirmed by the comments of participants. Some participants felt less satisfied with the quality of the VR application and they highlighted the developer’s lack of expertise in art. In general, a virtual reproduction can contain information that a physical exhibition in a museum showcase cannot. However, this VR application did not provide the participant with adequate information about the artwork and the artist (20.8%). Although the interaction was proper (40.2%), the VR application needed to improve several technical problems such as efficiency in navigation and orientation, user control, and visibility, based on the frequency data

(Table 21). In addition, sound effect was rated lowest among the detail factors of PEOU. As a matter of fact, a majority participant complained that the background music did not match the VR applications. I conducted a correlation analysis and found that the detail factors of PEOU not only had a significant correlation with DOS but also influenced the DOI of the VR application (Table 22). As a result, there was no statistically significant correlation between previous using experiences with the VR application and the detail factors of PEOU.

Table. 21: Ratio of Detail Factors of PEOU (%)

Detail Factors of PEOU	Ratio
Informativeness	20.8.
Efficiency in navigation and orientation	20.7
User control	25.6
Visibility	21.4
Interaction	40.2
Presence	47.7
Sound effect	19.1

Table. 22: Correlation Detail Factors of PEOU and DOS and DOI (** $p < .01$)

Detail Factors of PEOU	DOS	DOI
Informativeness	.610**	.832**
Navigation and orientation	.786**	.811**
User control	.678**	.808**
Visibility	.613**	.435**
Interactivity	.661**	.787**
Presence	.637**	.828**

7. CONCLUSION

Over the last decades, there has been an effort to shift the museum’s focus from the aesthetic value of museum artifacts to the historical information they encompass and the ideas they foster [30]. Historical narrative establishes connectedness between the museum objects, visitors, and various layers of information concerning their past context [31]. This changing perspective led museums to concentrate on the semantic meaning and various layers of information about objects through technological innovation. Museum professionals who oppose the employment of ICT in the museum field refer to Walter Benjamin’s concept of aura to claim the superiority of the unmediated experience with the museum object over the mediated experience via technology. In addition, some researchers argue that the aura and the essence of the artwork become irretrievably lost in the process of technological reproduction [32].

Unlike the previous researches dealing with digital exhibitions, this study differentiated in

that it dealt with the influence between digital exhibition and virtual reality application used in exhibitions. In particular, by comparing the degree of satisfaction and immersion of the aforementioned exhibition and virtual reality application, the characteristics of the user experience of technology acceptance and authentic experience in the digital and virtual reality environments were highlighted. The novelty of this study lies in the characteristics of super-disciplinary convergence research dealing with art, virtual reality and digital technology. In addition, by using TAM to measure artistic experiences in technological mediated environments in terms of PU and PEOU, from an academic point of view, this study proves that the TAM is appropriate for the design and evaluation of user experiences in interactive digital exhibitions and virtual reality applications.

To summarize the evaluation results of the participants' experiences with <Klimt Inside>, the DOS and the DOI turned out to be relatively low, compared to other digital exhibitions. In particular, nearly 30.0% of the participants pointed out the lack of a sense of immersion. The importance of immersiveness of exhibit media was confirmed through the correlation analysis between the immersiveness of exhibit media and the DOS, and between the immersiveness of exhibit media and the DOI. The DOS correlated with the DOI and the BIDE. The ratios of UFL factors were more highly rated than those of UFA factors and the SFL was as high as twice the SFA in terms of PU. The PVE with the originals of Klimt negatively influenced UFA. The DOS and the DOI had correlations with the detail factors of UFL and UFA. Unlike previous studies, in which the influence of SF was dominant, the impact of EF was revealed in this study. All detail factors of PEOU positively correlated with DOS and DOI.

In the case of the evaluation of <Stoclet Frieese>, the VR application was less satisfied than the digital exhibition and more immersive than the exhibition. The DOS with the VR application had a significant correlation with the DOI with the VR application, the IRA 1, the IRA 2 and the IOUA. However, the DOS with the VR application did not affect the DOS and DOI with <Klimt Inside>. The ratios of UFL factors were more highly rated than those of UFA factors and the SFL also was higher than the SFA in terms of PU. These results were

consistent with the results from the digital exhibition.

From the perspective of UFL, both <Klimt Inside> and <Stoclet Frieese> stimulated intrinsic motivations for learning and enhanced participants' understanding of the artworks and the artists to some extent. These reproductions might allow participants to engage in the vision of artwork prior to seeing the original, thus helping them to get acquainted with the artwork. In this study, I support and defend Bruno Latour and Adam Lowe's position that the aura of an art object can migrate along the trajectory by means of its reproductions under the conditions of ensuring accuracy, understanding, and respect of works of art. However, artistic value, properties, authenticity, and aura of the original did not properly mitigate the reproductions in terms of UFA. In this instance, pictorial sameness of these reproductions did not promise aesthetic sameness of the original. To be more specific, although <Klimt Inside> and <Stoclet Frieese> captured the physical properties of the original in terms of pictorial sameness, they were not as aesthetically valuable as the originals for the participants. Most importantly, these technological reproductions never fully substitute the originals. In fact, these reproductions were designed and developed through the complex technological remediate process of recontextualization and/or decontextualization by commercial studios. As a result, there was a detachment in terms of accuracy, understanding, and respect toward the original artwork of Gustav Klimt.

Both digital and virtual reproduction should be engaging and legible so as to be correctly interpreted and to stimulate thought, trigger enjoyment, inspiration and creativity, and reflect human curiosity and emotions. For example, <Bruegel: Unseen Masterpieces>, created by the Google Cultural Institute, is the virtual reproduction of Bruegel's <The Fall of the Rebel Angels>. It allows users to delve into the works of Pieter Bruegel. Drawing on a wide spectrum of virtual and on-site experiences, this VR application offers users a chance to immerse themselves in Bruegel's works by honing on the details of the painting and accessing expert knowledge. This innovative media with ultra-high resolution gigapixel image is the fruit of in-depth thinking on current transformations in the field of museology as it adapts to the digital era.

To sum up, both <Klimt Inside> and <Stoclet Frieze> did not guarantee the same quality of the original; however, the benefits of these technological reproductions are noteworthy: these reproductions can serve as a means for stimulating intrinsic motivation for learning; they can offer meaningfulness in the cognitive process of learning; and they can encourage participants to engage in meaningful dialogue on art. They also allow participants to engage in the vision of artwork prior to seeing the original, thus helping them to get acquainted with or more familiar with the artworks. As more museums are exploring ICT and VR technology in their exhibition environments, not only good collaboration must be ensured between museum professionals and technology specialists to achieve optimal results, but also the insight on the visitor experience through in-depth and on-going research on the adoption of technologies is required to enrich visitor engagement.

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