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Designing Perferable Virtual Worlds: An Analogy of Space

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ABSTRACT

Based on an analogy of space, this study adopted two 2D-based web usability models, namely landscape preference model (LPM) and architectural quality model (AQM), to test their applicability in 3D-based virtual worlds. An exploratory cross-sectional study with Second Life users was conducted and data were analyzed using a partial least squares (PLS) technique. The findings of this study demonstrate that these models have strong psychometric properties and explain a large amount of variance of the attitudes and perceptions of virtual world users associated with its usability factors. For LPM, except for significant legibility-affective appraisal path and insignificant variety-cognitive appraisal path, all paths in the original model were confirmed. For AQM, all relationships held except an insignificant external security-firmness relationship. Although further investigation is warranted, the findings indicate these models can successfully be used as theoretical alternatives to design usable virtual worlds. Key implications for theory and practice are discussed.

KEYWORDS

Virtual Worlds, Usability, Interface Design

INTRODUCTION

Virtual worlds, defined as "a computer-generated three-dimensional virtual space to interact with the projected identities of other users (so called "avatars") and virtual world objects", now become a reality (Campbell et al., 2007, p.29). They transport elements of the real world into cyberspace to supply online entertainment and social networking for users and to build a virtual commerce storefront for marketers and merchants. A number of virtual worlds such as Second Life, There, and Entropia have launched and continued to grow as highly interactive, collaborative, and commercial cyberspaces. Users select and reside in their preferred virtual places including online social communities, educational institutions, government, professional communities, and commercial ventures.

Like traditional web sites, creating a usable interface is one of the critical success factors for virtual worlds. This is because visitors' perceptions toward a particular virtual world are closely linked to the design quality of the interface with which they interact. Using avatars, which are effigies of human beings in a virtual space, and using astonishing virtual reality techniques, virtual worlds create spaces that take us close to a representation of real life (Junglas and Steel, 2007). With the increased amount of attention on the issue of creating a usable virtual place from researchers in human-computer interaction, there has been a great deal of speculation on the design of usable virtual worlds. However, a guiding design theory is still unavailable. Nielsen (2000) indicated that designing webs without a theory of web usability is like building houses without using any guiding principles of construction theory. Therefore, it is imperative to develop a theoretical framework for designing a usable interface of virtual worlds.

The primary objective of this study is, as an exploratory study, to test the applicability of two extant theoretical models of website usability such as Kaplan's landscape preference model (LPM) (Kaplan and Kaplan, 1989) and Vitruvius's architectural quality model (AQM) (Kim et al. 2002) to the design of a usable interface of virtual worlds. Philosophers such as Feyerabend (1963) support an analogy-based new theory development process under the absence of an agreed belief system ("theory") to understand a newly emerged phenomenon. Based on the analogy of a virtual space as a physical place, this study selects a theory from environmental psychology (i.e., LPM) and a theory from architecture (i.e., AQM) which were originally developed to address usable and beautiful physical space (or artifact) design. In addition to physical spaces, the models have been empirically tested and validated in a variety of cyber space design contexts such as utilitarian and hedonic e-business websites (Hong and Kim, 2004), online travel sites (Lee and Kozar, 2009), and a home page of a small greeting card gifts manufacturer (Singh et al., 2005).

THEORETICAL BACKGROUND

This study selects two theoretical models, Kaplan's landscape preference model from environmental psychology and the architectural quality model from architecture, to apply to the design of a usable interface for virtual worlds. These theories have been adopted by human computer interaction (HCI) researchers to address usable website design and were found to be applicable. This study represents an extension of that work into the virtual world environment.

ARCHITECTURAL QUALITY MODEL: To assess the quality of buildings, researchers in architecture have developed conceptual models of architectural quality (Giedion, 1941), consisting of three interrelated constructs: firmness, utility and delight. A building characterized as having strong firmness, suitable space allocation, and pleasant appearance can be evaluated as a highly attractive one. In HCI, interface design has often been depicted in the same light as building construction because creating a website in a virtual space is similar to constructing a building in a physical space. Just as a builder constructs a building by using a variety of materials (e.g., wood, concrete, mirror, tile) and then selectively combining them to create a new physical space, a web designer creates a website using a variety of design components (e.g. text, images, color, sound) and then selectively combining them to create a new virtual space.

Recently, this theory has been adopted and validated by IS researchers to develop a theoretical model for measuring the design quality of a website. For example, Kim and his colleagues (Kim et al., 2002; Hong and Kim, 2004) developed a theoretical model of website usability by adopting this theory and found that three architectural quality factors captured a large amount of variance in online users' satisfaction and loyalty for a website. Virtual worlds such as Second Life (SL) can be conceptualized as consisting of a variety of artifacts, particularly virtual buildings. Therefore, the design quality of the metaverse can be assessed by the use of factors that measure the quality of buildings in physical space. Table 1 summarizes the definitions of architectural quality factors in both physical space and the virtual world context and their implementations in the SL environment.

Factors	Physical Space	Virtual Worlds	Second Life Features
Firmness	The extent to which a building is robust enough to protect its residents from all environmental threats	The solidity of the system structure in overcoming all expected and unexpected threats. *Internal Reliability*: The operational stability of virtual worlds *External Security*: The safety of virtual worlds from external threats	Internal Reliability: Backup blog servers, Inventory operations reliability enhancement patch, opening up the Linden server code to the open source community to improve system reliability External Security: Abuse Report, Copyright Protection, Privacy Protection, Terms of Service and Community Standards
Utility	The appropriate allocation of space in a building	Appropriate features for the users' interactions with the system. *Content Usefulness*: The quality of information provided in virtual worlds *Navigation Usability*: The ease of navigation of virtual worlds.	Content Usefulness: Repository, Bookshelf, Help Islands, Orientation Islands Navigation Usability: Landmark, Teleport, Fly, Mini-map
Delight	The visual appeal of a building	The pleasantness of overall virtual worlds interface *System Interface Attractiveness*: The pleasantness of the virtual worlds interface *Communication Interface Attractiveness*: The pleasantness of the communication interfaces (or features) between users	System Interface Attractiveness: Use consistent structures, Menus, short cuts, colors, avatars, and movement Communication Interface Attractiveness: - Local chat (shout and whisper): between two or more avatars within 20 meter - Global instant messaging: between two avatars or among the member of a group - Voice chat using Vivox technology

Table 1. Summary of Architectural Quality Factors and Their Implementation in Virtual Worlds

LANDSCAPE PREFERENCE MODEL: Kaplan's model has been recognized as a representative theoretical framework for scenic preference assessment in the environmental psychology field (Kaplan and Kaplan, 1989). The model examines physical environments in an attempt to identify design patterns that incorporate the end users' utilization of environmental cues, thus making it easier for people to process information and function enjoyably and effectively.

The model explains landscape preference based on a two- and three-dimensional visual perception. The model depicts humans as cognitive creatures who can compute the future possibilities of present landscape choices. The calculation consists of both immediate and future calculations, which can occur quickly but sequentially. Immediate (two-dimensional) perceptions are related to coherence and variety, whereas future (three-dimensional) perceptions are related to legibility and mystery. Past studies have validated the model in various contexts. For example, Singh et al. (2005) and Rosen and Purinton (2004) adopted the model to develop the theoretical framework of website usability and found it to exhibit strong explanatory power to capture the influence of website design factors on online users' perceptions toward a website.

The model can be successfully applied in the usable interface design of virtual worlds since as with physical landscape in physical space, virtual worlds contain a virtual landscape. Thus, major constructs of the original model are pertinent to assess the preference of online visitors toward virtual worlds. Online visitors build positive attitude toward virtual worlds when they can grasp its structure, content, and features in a few seconds, can easily navigate without becoming disoriented, can enjoy vivid and dynamic images and other multimedia, and can be stimulated with features inspiring their curiosity. Recently, Lee and Kozar (2009) elaborated these relationships by separating attitude into cognitive and affective appraisal. They found a significant effect of legibility, coherence, and variety on cognitive appraisal and of legibility, variety, and mystery on affective appraisal. Table 2 summarizes the relationship between architectural quality factors in both physical space and the virtual world.

Factor	Physical Space	Virtual Worlds	Second Life Features
Legibility	Ease of navigating a scene with centrality of orientation	The capability of virtual worlds to provide easy interaction and navigation.	- Landmark: a geographic location in SL - Teleport: instantaneous travel between one point on the grid to another - Fly: 170 meter above the terrain - Mini-map
Coherence	The ease of grasping the organization of the scene	The capability of virtual worlds to provide consistent and orderly contents, structures, and multimedia components within and across sites/pages.	- Consistent menus, help, navigation, walk, chat - Repeating structures and unifying textures that contribute to a good gestalt
Variety	Diversity in a scene	The capability of virtual worlds to provide diverse components which create vivid interaction and communication with online customers	- Local chat (shout and whisper) - Global instant messaging: between two avatars or among the member of a group - Voice chat using Vivox technology - Customize avatars and their shape, skin, hair, eyes, and attachments
Mystery	The opportunity to gain new information while investigating a concealed landscape, which was unseen at first glance	The capability of virtual worlds to invoke curiosity and interest and stimulate further navigation.	A variety of unseen and unexplored avatars, places, and transportation, flash arrow, continue, exit

Table 2. Summary of Landscape Preference Factors and Their Implementation in Virtual Worlds

RESEARCH METHODOLOGY

To test the applicability of the two existing theoretical models of website usability in virtual worlds, this study conducted a questionnaire-based field survey. The population of the main study was online users who had visited a virtual world environment at least one time. The study was advertised in the student newspaper, Facebook, and in spring-semester classes at a large Midwestern US university resulting in a total of seventy-one subjects. Second Life (SL), currently the most popular and successful virtual world, was the target virtual world. We selected SL mainly because of the relative convenience of recruiting subjects and the easy comparability of research findings with previous studies. Participants were requested to come into a computer lab and navigate SL following lab coordinators' instruction. Upon experiencing the SL environment, the participants completed an online questionnaire. Participation was voluntary and took approximately forty minutes. Subjects were compensated by an award of class participation points.

Instruments were developed using scientific instrument development processes (e.g., Straub 1989). The initial instrument items were originally developed through an extensive literature review of the previous studies of web usability (e.g. Koufaris, 2002), landscape preference model (e.g., Lee and Kozar, 2009), and architectural quality model (e.g. Hong and Kim, 2004). The instrument items were operationalized to fit the context of virtual worlds and were then pretested with five experts who are familiar with website usability, virtual worlds, and instrument development to verify their content validity. Through this process, the wording, order of items, content, and format of the questionnaire were revised. Finally, a pilot test was conducted to validate the instruments. The instrument items used for the survey are shown in the Appendix.

RESULTS

The research model was tested using PLS 3.0. Compared to LISREL, AMOS, and EQS, PLS allows flexibility to represent both formative and reflective constructs and places minimal demands on sample size, measurement scales, and residual distributions (Wold, 1982).

Landscape Preference Model (LPM)

MEASUREMENT MODEL ANALYSIS: A measurement model analysis was conducted to examine psychometric properties of the measures for latent constructs. Testing of the measurement model was done by examining (1) internal consistency, (2) convergent validity, and (3) discriminant validity. Internal consistency was measured using the composite reliability (CR) metric. Composite reliability greater than 0.7 is considered adequate (Hair et al., 1998). Table 3 (column entitled 'CR') shows the internal consistency of each construct used in this study. All constructs were well above the cut-off value of 0.7 and met the recommended criterion. Convergent and discriminant validity can be assessed by applying two criteria: (1) the square root of the average variance extracted (AVE) by a construct from its indicators should be at least 0.707 (i.e., AVE > 0.5) and should be greater than the variance shared between the construct and other constructs in the model, and (2) standardized item loadings should be at least 0.707, and no measurement item should weigh more heavily on other constructs than the construct it intends to measure. As shown in Table 3, the square root of AVE for each construct was greater than 0.707 (see the values in the diagonal of Table 3), and all constructs shared more variance with their own indicators than with other constructs. In addition, the factor structure matrix (see Table 4) showed that all indicators exhibited a high weight on their own constructs and no items weighed more heavily on those constructs which were not intended to be measured. Therefore, convergent and discriminant validity were confirmed. Finally, all construct values of Cronbach's α (see Table 3) were greater than 0.7, indicating sufficient reliability.

	CR	α	1	2	3	4	5	6	7
1. Legibility	0.902	0.858	**0.835**						
2. Coherence	0.919	0.883	0.391	**0.861**					
3. Variety	0.923	0.887	0.451	0.420	**0.867**				
4. Mystery	0.957	0.939	0.451	0.415	0.561	**0.920**			
5. Cognitive Appraisal	0.970	0.959	0.522	0.432	0.195	0.377	**0.944**		
6. Affective Appraisal	0.946	0.923	0.514	0.539	0.604	0.689	0.500	**0.903**	
7. Behavioral Intention	0.921	0.868	0.178	0.255	0.307	0.380	0.418	0.442	**0.892**

Table 3. Inter-construct Correlation Matrix

		1	2	3	4	5	6	7
1. Legibility	LEG1	**0.867**	0.480	0.395	0.388	0.528	0.474	0.195
	LEG2	**0.863**	0.276	0.330	0.478	0.543	0.463	0.199
	LEG3	**0.832**	0.315	0.393	0.309	0.324	0.387	0.031
	LEG4	**0.779**	0.191	0.420	0.292	0.262	0.369	0.134
2. Coherence	COH1	0.444	**0.887**	0.432	0.380	0.388	0.502	0.141
	COH2	0.483	**0.891**	0.407	0.434	0.411	0.552	0.201
	COH3	0.243	**0.877**	0.295	0.246	0.375	0.369	0.284
	COH4	0.124	**0.783**	0.299	0.369	0.304	0.423	0.269
3. Variety	VAR1	0.359	0.489	**0.794**	0.343	0.087	0.463	0.208
	VAR2	0.476	0.367	**0.901**	0.501	0.287	0.603	0.316

	VAR3	0.415	0.334	**0.920**	0.594	0.210	0.555	0.300
	VAR4	0.271	0.274	**0.843**	0.483	0.021	0.438	0.213
4. Mystery	MYS1	0.477	0.309	0.508	**0.887**	0.359	0.599	0.335
	MYS2	0.419	0.321	0.483	**0.943**	0.316	0.655	0.370
	MYS3	0.409	0.427	0.549	**0.931**	0.397	0.659	0.379
	MYS4	0.359	0.468	0.524	**0.918**	0.316	0.621	0.312
5. Cognitive Appraisal	COG1	0.488	0.390	0.149	0.319	**0.944**	0.435	0.405
	COG2	0.493	0.454	0.159	0.347	**0.944**	0.464	0.399
	COG3	0.507	0.375	0.197	0.376	**0.946**	0.517	0.391
	COG4	0.482	0.412	0.233	0.385	**0.941**	0.472	0.383
6. Affective Appraisal	AFF1	0.417	0.447	0.605	0.643	0.396	**0.889**	0.468
	AFF2	0.424	0.397	0.364	0.522	0.428	**0.859**	0.272
	AFF3	0.475	0.533	0.570	0.702	0.428	**0.950**	0.371
	AFF4	0.535	0.551	0.600	0.603	0.551	**0.913**	0.454
7. Behavioral Intention	EFF1	0.266	0.191	0.353	0.353	0.369	0.411	**0.867**
	EFF2	0.162	0.259	0.272	0.272	0.357	0.361	**0.921**
	EFF3	0.048	0.233	0.194	0.382	0.387	0.403	**0.880**

Table 4. Factor Structure Matrix of Loadings and Cross-Loadings

STRUCTURAL MODEL ANALYSIS: Figure 1 shows the results of the structural model analysis. Following Wold's guideline (1982), a bootstrapping test was conducted to find estimates of standard errors for testing the statistical significance of path coefficients using t-tests. For the landscape preference model, 57.1 % of the total variance of the affective appraisal, 34.9% of cognitive appraisal and 24.7 % of the behavioral intention were explained. Except for the *variety-cognitive appraisal* path (β = 0.146, p >0.05), all nomological networks turned out to be significant.

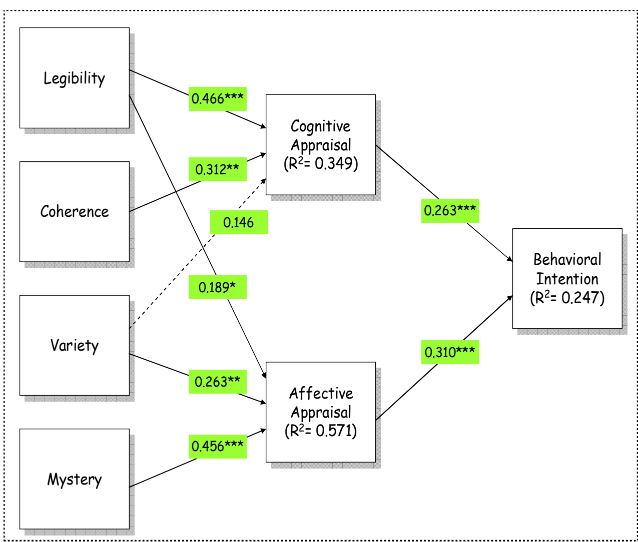

Figure 1. Results of Structural Model Analysis (LPM)

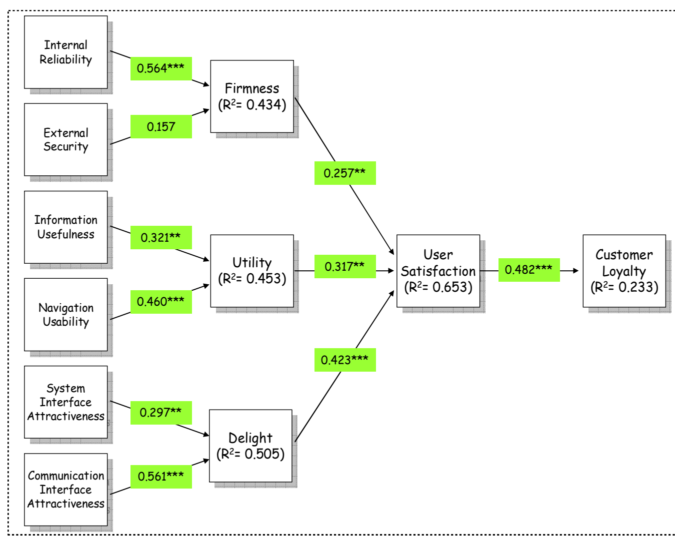

Figure 2. Results of Structural Model Analysis (AQM)

Architectural Quality Model (AQM)

We used the same technique used for LPM to assess the measurement and structural model of AQM. The measurement model analysis showed internal reliability, and convergent and discriminant validity were confirmed (detailed results and tables are available by request to the first author). All composite reliability was greater than 0.7, all square roots of the average variance extracted (AVE) were greater than 0.707; standardized item loadings were at least 0.707; and no measurement item weighed more heavily on other constructs than the construct it is intended to measure. Cronbach's α was also greater than 0.7, indicating acceptable reliability. Structural model analysis (see Figure 2) showed that 65.3 % of the total variance of satisfaction and 23.3 % of customer loyalty were explained. All nomological networks except the *external security - firmness* path ($\beta = 0.157$, $p > 0.05$) were confirmed.

Since measures of all constructs in the study were gathered at the same point in time, this study examined the common method bias following the Marker Variable (MV) technique of Malhotra et al. (2006). We used fashion consciousness of Malhotra et al. as a marker variable which is theoretically unrelated to at least one variable in the study. We first conducted a correlation analysis to find the value of the marker variable and found that it was 0.013. Then, by putting it into the formula provided by Malhotra et al. (see. p. 1868), we created adjusted correlation estimates and t-statistics. As a result, we found that none of the original correlations were significantly different from their CMV-adjusted counterparts, implying that there were no substantial biases.

DISCUSSION AND CONCLUSIONS

Our findings demonstrate that both the landscape preference model and the architectural quality model have strong psychometric properties and explain a large amount of variance of the attitudes and perceptions of virtual world users. The results imply that although further elaboration is warranted, these models can be used as alternative theoretical models to assess the usability of virtual worlds. We further discuss our findings and their implications below.

Landscape Preference Model: Compared to previous studies (e.g., Lee and Kozar, 2009), affective appraisal had the stronger influence on behavioral intention than cognitive appraisal. This finding indicates that the users' interaction with the virtual world which utilizes multiple media and richer, graphical 3D interfaces is both pleasurable and enjoyable, which triggers a stronger intention to revisit and spend more time and interacting with others. Compared to previous information systems developed to deliver mainly functional values, contemporary information systems including virtual worlds have been challenged to incorporate many hedonic features to meet users' needs of perceiving enjoyment, fun, and arousal while using them (Zhang and Li, 2005). Our findings suggest that developers of virtual worlds put additional efforts in considering more pleasurable design components. The significance of the legibility-affective appraisal path was an interesting finding since the path was insignificant in the web environment. This implies that diverse navigation support tools in virtual worlds such as teleport, fly, and landmark not only provide users with convenience of movement, but also provide them with excitement while trying or playing with it. This suggests that designers place their endeavor on developing a variety of navigation support tools providing a fun user experience beyond basic utilitarian functionality. Researchers of online flow (Novak et al., 2000) and cognitive absorption (Agarwal and Karahanna, 1999) have supported this relationship. Finally, mystery was found to be the strongest factor affecting affective appraisal, indicating that users stimulated with high levels of interest and curiosity in exploring the unseen cyberspace or meeting simulated avatars perceived a higher level of enjoyment.

Architectural Quality Model: All architectural quality factors showed significant relationships with user satisfaction, which triggers his/her loyalty to the virtual worlds. Like LPM, delight was found to be the strongest factor affecting user satisfaction, indicating that pleasantness experienced while using system features and interacting with others in virtual worlds gives users the highest level of satisfaction. The insignificant relationship between external security and firmness was unexpected. However, this does not mean that users did not consider security as unimportant in virtual spaces. One possible interpretation is that most users did not meticulously assess the security of the virtual worlds because they did not pay attention to their built-in security features. The high variance of user responses on this construct is the evidence to support this reasoning. Navigation usability had a greater impact on utility than information usefulness. The lack of content in the early stages of the virtual world development has been widely recognized. To alleviate this drawback it could be recommended to developers to not only create virtual world content themselves but also to consider incentives for motivating visitors to produce it. Sharing island ownership, acknowledgement of top contributors, and Linden dollar (SL currency) awards are possible alternatives.

This study does have several limitations that should be revisited in the future. This study has a low external validity with regard to the subjects and the research setting that the study took place in. The participants of the study were college students. Although student subjects can represent the target population of virtual world users, future work with actual users of a real virtual world environment is necessary to test the generalizability of these research findings. The small sample size is another limitation. Although virtual worlds are in an early adoption stage with only a limited user population and it was extremely difficult to recruit the large number of subjects, future replicated studies with a larger sample size are recommended. A larger number of subjects allows researchers to investigate the influence of personal (e.g., personality, experience), technical (e.g., avatars), and environmental characteristics (e.g., type of site) on users' perceptions and behaviors in virtual worlds. Since this study measures all variables at the same point in time, it is likely to be exposed to the common method variance (CMV) problem. Despite the findings of no significant CMV, it is recommended that future work attempt to avoid the CMV problem by conducting such a study as a longitudinal study.

This study is expected to provide useful insights for both researchers and practitioners. From a theoretical perspective, this study examines the applicability of two existing web usability models in virtual world design. Considering that virtual worlds will continue to advance and become more prevalent as their use expands to include more social networking, virtual education, and even virtual business applications, the models can be used as theoretical alternatives for usable interface design of virtual worlds. These models, which have a special focus on artifacts and system environment design respectively, can be combined to develop a holistic model of usable virtual worlds. Furthermore, the validated measures can be used for future replicating studies to test the models in various virtual world sites. From a practical perspective, this study provides a useful guideline for designers to develop a usable virtual world. By using the resulting model and its instrument items, designers can evaluate the usability of their current virtual worlds, compare results to the designs of competitors, and upgrade the offerings of virtual worlds by allocating the limited available resources to the most influential design factors.

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APPENDIX. INSTRUMENT ITEMS

Construct	Items
Coherence	Each component of the virtual world is well related to each other. Components of the virtual world work well together. Each component of the virtual world seems to hang together. Each component of the virtual world helps the others to provide better comprehension to visitors.
Legibility	It is clear where I can go in the virtual world. It is easy to get around the whole virtual world. It does not take much time to figure out a way of moving around the virtual world. I can always figure out where I am while navigating the virtual world.
Variety	The virtual world has too many distractions, making it confusing. The virtual world does not contain enough components to interest me. The virtual world contains a good variety of components that keep me involved. I feel drawn in by the variety of information or artifacts the virtual world offers.
Mystery	The virtual world makes me feel there is something interesting to explore. As I navigate through the virtual world, an increase in curiosity inspires me to continue to explore. I expect the virtual world will provide interesting things to increase my curiosity as I explore. I feel I will find interesting things if I navigate more in the virtual world.
Cognitive Appraisal	The virtual world is effective to achieve the goals of any future visits The virtual world is convenient to attain the goals of any future visits I feel comfortable using the virtual world to achieve the goals of any future visits The virtual world is helpful to achieve the goals of any future visits
Affective Appraisal	I would describe my overall experience while visiting the virtual world as Exciting Pleasant Interesting Enjoyable
Behavioral Intention	I intend to revisit this virtual world when necessary. I predict I would spend more time in this virtual world than other sites. I expect I will interact with other visitors while visiting the virtual world.

Instrument Items of Landscape Preference Model

Construct	Items
Robustness	The virtual world is stable in general. The virtual world is dependable in general. I can use the virtual world without worry.
External Security	The virtual world has strong protection against any unauthorized access attempts from outside. The virtual world exercises enough precaution to provide a safe place in the virtual environment. The virtual world has a strict policy to protect private information of its members.
Internal Reliability	The virtual world quickly responds to my requests in a consistent manner. The virtual world operates stably in the process of exchanging information and interacting with other visitors.
Utility	It is easy to use the virtual world in general. I can get useful information from the virtual world. I can navigate the virtual world conveniently.
Information Usefulness	The information acquired from the virtual world is objective. The information acquired from the virtual world is accurate. The information acquired from the virtual world is frequently updated. The virtual world contains many valuable contents.
Navigation Usability	It is easy to identify the current location in the virtual world. It is easy to understand the navigation structure of the virtual world. It is easy to navigate the virtual world toward the target location.
Delight	It is interesting to use the virtual world. The process of using the virtual world is delightful. I like the look and feel of the virtual world.
SI Attractiveness	The virtual world uses appropriate colors for its screens. The virtual world has attractive screen layouts. The virtual world has a well-diversified screen design.
CI Attractiveness	I can communicate with other visitors pleasantly within the virtual world. The virtual world provides a comfortable cyber place for meeting other users. The virtual world promotes an atmosphere for intimate meeting with other users.
Satisfaction	Overall, I am satisfied with the virtual world.
Loyalty	I am going to revisit this virtual world when necessary.

Instrument Items of Architectural Quality Model