Effects of Demographics and Computer Usage Characteristics as Moderators on Importance of Quality Factors for Virtual Reality Commerce Interface

Satidchoke Phosaard[a*], Pimmanee Rattanawicha[b], and Wachara Chantatub[b]
[a]School of Information Technology, Suranaree University of Technology,
111 University Avenue, Nakhon Ratchasima 30000, Thailand
[b]Department of Statistics, Chulalongkorn Business School,
Chulalongkorn Univerisity, Bangkok 10330, Thailand
*Corresponding Author: s@sut.ac.th

ABSTRACT

Virtual Reality (VR) is a promising alternative for the next generation online interface. It is important that the developed VR interfaces must satisfy a collection of good quality criteria, which are not widely available in the literature. This paper aims to determine interface preferences of different groups of users by studying moderating effects of demographics and computer usage characteristics of users as moderators on importance of quality factors for VR interface. VR commerce is selected for the study due to its importance. The study analyzed the moderating effects of gender, age, computer usage experience, computer usage per day, VR application/game usage, and e-commerce shopping experience by applying the independent sample t-test on the dichotomous groups of each moderator over quality factors derived from a two-stage factor identification. The results suggested that there was only one moderating effect of gender on the product searching feature.

Keyword: Virtual Reality Commerce Interface, Moderating Effects, Demographics, Computer Usage Characteristics, Web Quality

1. Introduction

In this age of the Internet, World-Wide-Web (WWW) is the prominent standard of the Internet applications. The standard is based on the Hypertext Mark-up Language (HTML) that typically combines texts, images, and other media, and presents them to users. Recently, there are promising powerful interfaces emerging as alternatives. Virtual Reality (VR) interface is one of the promising interfaces offering a highly interactive environment. VR is a human-computer interaction technology that lets the users interact with the computer simulated environment. The generated environment can be an environment of either a real world or an imaginary world. This VR environment, as well as similar 3D virtual world, has been introduced into

and studied in many application areas, such as entertainment, e.g. SecondLife (Linden Research, 2010); medical and education (Boulos, Hetherington, & Wheeler, 2007; Seymour et al., 2002); e-commerce (Jahng, Jain, & Ramamurthy, 2006; Lepouras & Vassilakis, 2006; Li, Daugherty, & Biocca, 2003; Lu & Smith, 2007; Najihah 2009); tourism, e.g. Thai Royal Palaces Virtual Tour (Bureau of The Royal Household, 2009); etc. Such highly interactive interface contains several distinct characteristics from general HTML web interface. It has been proven that it can offer superior experiences for certain tasks (Jahng et al., 2006; Li et al., 2003; Lu & Smith, 2007).

Among VR applications, VR commerce can be a potential candidate for wide adoption since its importance and advantages derived from VR interface. E-commerce becomes a common practice for trading. The huge market size and expanding trend intensify its pivotal role in local and global trading. In the United States alone, the retail sales on e-commerce reached at least 31.72 billion dollars in only a period of a quarter in the first quarter of 2009 (U.S. Department of Commerce, 2009). There are several e-commerce growth limitations. One of them is the e-commerce interface limitation. The e-commerce user interface limits the interaction between users and products, thus helping users acquire knowledge about products in such limitation is challenged, especially for particular types of products that require a high degree of interaction between consumers and products or services, e.g. a mobile phone that consumers would like to feel touch and use its features, a hotel room that the prospective guest might want to virtually walk around the room, etc. VR could be a solution. VR commerce customers will be able to get more insight into the product features leading to purchase intention, which has been presented in Lu (Lu & Smith, 2007) and Suh (Suh & Lee, 2005).

However, to achieve such highly interactive experiences in VR interface, the construction of virtual environments is considered to be more costly than general web interfaces. It is important that the developed VR interfaces should satisfy a collection of good quality criteria. Moreover, the evaluation of the system implementation success is a suggested critical practice for adopting an information system. Such criteria and measure for a good quality online VR interface was just available in literatures by the study of Phosaard and Rattanawicha (Phosaard & Rattanawicha, 2010). The ITAM study is among early research contributing in VR interface quality. The study indicated that there are seven stable factors the users preferred for an online VR commerce interface, which they referred to as good quality factors. The VR commerce interface or VR store was selected for the exploratory study due to its importance, adoption potential, as previously mentioned, and also

availability.

However, differences of each individual user might affect the perceived importance of each quality factor of the VR commerce interface. It is important to understand different preferences of each user groups, if any, so that it can be used as guidelines to offer customized interfaces that fit individuals. This study aims to determine whether there are such moderating effects of users' demographics: gender and age, and users' computer usage characteristics: computer usage experience, number of hours per daily use of computer, frequency of three dimensional interface use and e-commerce shopping experience, on users' preferences on importance of quality factors of VR commerce interface.

This paper is organized as follows. Background and theories are introduced in the next section. It is followed by the research methodology in the third section. Results and discussion are provided next in the fourth section. The last section, conclusion and future works, wraps up the main ideas presented and provides suggestions for future research.

2. Background and Theories

In this section, related theories and literatures are reviewed in the following order of topics: Virtual Reality (VR), Virtual Reality Commerce (VR-commerce) and web quality.

2.1 Virtual Reality

Virtual reality (VR) is a human-computer interaction technology that let the users interact with the computer simulated environment (Burdea & Coiffet, 2003). The generated environment can be either a real world or an imaginary world. To imitate the real-world experience, special visual devices are used, such as mask, wall-projected room, and so on. Nonetheless, common monitors can be used to provide a certain level of VR experience. Generally, VR in computer screen generates environments that the users found themselves submersed into the environment. Users can use special input device or a common keyboard and mouse to interact with the environment.

The ability of virtual reality to enhance the consumer abilities is based on three main properties: high media richness, interactivity and telepresense (Suh & Lee, 2005). Media richness theory (Daft, Lengel, & Trevino, 1987) claims that high uncertainty or ambiguity tasks need higher interaction or higher media richness to reduce the

uncertainty or ambiguity. In this case, VR can provide such high media richness through the interactivity. Such interactivity is achieved when the e-commerce site users manipulate the product and immediate get the information regarding the product features and appearance (Klein, 2001; Pimentel & Teixeira, 1994). Through VR, users can feeling the existing of telepresence (Biocca, 1997; Klein, 2001), which indicates a sense of "being there," in the remote environment through a mean of communication (Steuer, 1992). In this sense, we might expect telepresense-related quality factors to emerge from the study in addition to the quality factors for typical web interface.

2.2 Virtual Reality Commerce

Virtual reality commerce or VR-commerce is a type of e-commerce. The major difference of this type of e-commerce from general e-commerce sites is that its user interface is presented in a virtual reality manner. The VR-commerce site can incorporate AR capability. We can say that, in general, a VR-commerce site looks like a virtual shopping mall which users walk around a simulated shopping mall as they immersed into the screen. Thus, the interfaces are presented in three dimensions or 3D. Figure 1 shows an example of a VR-commerce website. General VR-commerce sites try to provide user interfaces that the users will get shopping experiences as realistic as possible. VR-commerce is getting attentions from researchers and business practitioners because of its uniqueness and abilities which former types of e-commerce cannot accomplish. There are various ways for the VR-commerce customers can interact with a VR-commerce system.

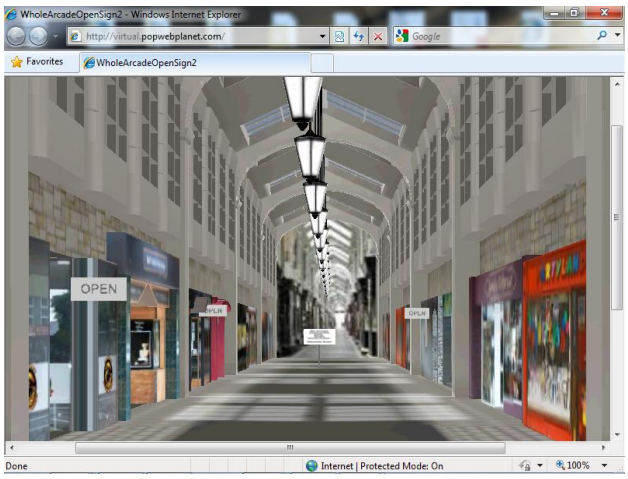

Figure 1 - A Virtual Shopping Mall (http://virtual.popwebplanet.com)

2.3 Web Quality

Web interface is one of the most prominent online interfaces of the era. The shifting of information system technology from the primitive years of standalone, PC-based

computers and mainframes triggered a handful of framework or guideline proposals for good quality webs as explained in (Aladwani & Palvia, 2002; Koyani et al., 2004), for example. As discussed, the superiority of VR interface could be a promising alternative for online interfaces. The study of determining good quality factors for this highly interactive interface can follow the studies or research in web quality.

According to an extensive review and analysis by Adel and Palvia (Aladwani & Palvia, 2002), web quality consisted of four major dimensions: appearance, specific content, content quality and technical adequacy. The study by Phosaard and Rattanawicha (Phosaard & Rattanawicha, 2010) suggested that there were 7 emerging quality factors and they were more correlated with the dimensions of appearance and technical adequacy, along with unidentified factors exclusively for online VR commerce interface rather than content dimensions. These quality factors will be investigated further in this study regarding moderating effects of demographics and computer usage characteristics of users.

3. Research Methodology

The objective of the study is to investigate:

> Are there any moderating effects on the importance of each quality factor by users' demographics and their computer usage characteristics?

To answer this research question, a study along a two-stage design according to Phosaard and Rattanawicha (Phosaard & Rattanawicha, 2010) was conducted.

3.1 Research Design

A self-report questionnaire was used for an empirical study of good quality factors. One week before the distribution of the questionnaire, the participants were introduced to several VR commerce interfaces, such as the one shown in Fig. 1, as well as other VR interfaces, e.g. the 360 degree view of car or house selling websites and so on. VR and 3D interface of the following websites were shown: secondlife.com, virtual.popwebplanet.com, lh.co.th, sansiri.com, lexus.com, samsung.com. The participants also asked to get familiar with the VR interface by installing the VR shell created by Phosaard and Tanthanuch (Phosaard & Tanthanuch, 2007) replacing their desktop for a week. The study then followed by applying statistical analyses on the collected data. The moderating effects between groups of users by demographic data and computer usage characteristics were analyzed by a series of independent sample t-test.

3.2 Research Instrument

A questionnaire survey from (Phosaard & Rattanawicha, 2010) was adopted. The self-report questionnaire consists of two parts. The first part contains six personal information questions: two questions for demographic information, which are 1) gender and 2) age; four questions for related computer usage characteristics: 3) computer usage experience, 4) computer usage per day, 5) virtual reality application/game usage, and 6) e-commerce shopping experience. There are two choices of 1) male and 2) female for the gender question; five choices of 1) never, 2) rarely—less than once a month, 3) occasionally—at least once a month, 4) frequently—at least once a week, and 5) everyday, for the VR application/game usage question; and two choices of 1) no and 2) yes for the question asking whether the respondents use to shop online or not. For questions of age, computer usage experience, and computer usage per day, the respondents were asked to put in a number for each question as year, for the first two questions and as hour for the last question. This part of the questionnaire contains variables that we studied as moderators for importance ratings of VR commerce interface quality factors measured from the following part.

The second part of the survey contains 54 VR interface features/elements according to the first stage of the study (Phosaard & Rattanawicha, 2010). Only 20 items will be used in the moderating analysis; the rest of the items, 34 items, were collected for future study and were excluded from the analysis. The respondents were asked to rate the importance of the features/elements in general VR commerce interface on a 5-Likert scale from extremely important (5) to extremely not important (1). The extremely important rating was selected if the respondents find that those features/elements are required for the adoption of such interface.

3.3 Participants

Respondents can be general computer users with good understanding of VR commerce interface but expertise on it was not required. Undergraduate students were able to be the targets. 144 questionnaire respondents were mostly sophomore undergraduate students in IT major, aged 18-23, registering for a Web Technology class. 71.5% of them are female while 28.5% are male. They had average computer usage experiences of 8.69 years, and use computer on an average of 8.68 hours per day. 13.3% of the respondents never had experience with virtual reality applications or games before we introduced the interfaces while 76.7% already had. 85.9% used to shop or look for product information online while 14.1% did not.

4. Results and Discussion

According to the suggested 8 quality factors of VR commerce interface by Phosaard and Rattanawicha (Phosaard & Rattanawicha, 2010), table 1 summarizes questionnaire results of users preferences on the importance of each item. The averages of items associated in each factor represent importance of the factors. From the results, users rated the importance of *Atmospheric Experience* as 3.95 (SD. 0.95), *Content Finding* as 4.03 (SD. 0.90), *Decorative Elements* as 3.82 (SD. 0.96), *Place Familiarity* as 3.79 (SD. 0.94), *Standard Appearance* as 4.00 (SD. 0.81), *Aspect Fit* as 4.26 (SD. 0.73), *Acceleration Capability* as 4.06 (SD. 0.86), and *Basic Virtual Reality Experience* as 4.29 (SD. 0.86). In this study, would like to find out whether the demographic data and computer usage characteristics of users significantly affect their preference of quality factor importance. Thus, the moderating effects of both demographics and computer usage characteristics were analyzed.

Table 1 – Users' Preferences on Importance of Quality Factors of VR Commerce Interface

Online VR interface quality factor	No. of items	Mean	SD.
Atmospheric Experience	**4**	**3.95**	**0.95**
Seasonal activities		4.11	0.95
Cashier's counter		3.92	0.86
Event synchronization		3.91	1.03
Elevator		3.84	0.94
Content Finding	**1**	**4.03**	**0.90**
Direct searching for products		4.03	0.90
Decorative Elements	**3**	**3.82**	**0.96**
Innovative elements		4.08	0.78
Decorative elements		3.90	0.91
Scenic viewpoints		3.46	1.06
Place Familiarity	**2**	**3.79**	**0.94**
Layout familiarity		3.85	0.95
Product department familiarity		3.72	0.94
Standard Appearance	**3**	**4.00**	**0.81**
Proper use of colors		4.16	0.76
Proper use of fonts		3.94	0.79
Layout customization		3.90	0.85
Aspect Fit	**2**	**4.26**	**0.73**
Proper product size		4.32	0.70
Proper use of camera's view		4.19	0.75
Acceleration Capability	**2**	**4.06**	**0.86**
Zoom in/out capability		4.14	0.83
Speed-up navigation capability		3.96	0.89
Basic Virtual Reality Experience	**3**	**4.29**	**0.86**
Overall reality		4.40	0.81
Touch screen interface capability		4.24	0.94
Animated elements		4.22	0.83

To determine the existence of moderating effects, a two group/two level group method was employed. The participant cases were categorized into two groups by each studied moderators. The expected moderators are gender, age, computer usage experience, computer usage per day, virtual reality application/game usage, and e-commerce shopping experience. In case of categorical variables, which are gender and e-commerce shopping experience, cases were divided by the value 1 and 2 of each group as they represent. While, in case of scale valuables, which are age, computer usage experience and computer use per day, and an ordinal variable, which is VR application/game usage, cases were categorized into two level groups, high and low. We divided cases in the latter group of variables by their means, since mean are not susceptible to extreme-value cases. Then, the moderating effects can be assessed by comparing differences of the rated importance of each VR interface quality factors between the two groups of each expected moderator using the independent sample t-test. For example, to test whether there is a moderating effect of gender on the importance rating of atmospheric experience as a VR interface quality factor, an independent sample t-test is applied on the rated importance comparing the means between the male and female group. If the means of those two groups are significantly different, then it suggests that gender is one of the moderators affecting users' preference on the VR interface factor, the atmospheric experience factor. Table 2 shows the medians for categorizing cases of scale and ordinal variables.

Table 2 – Medians of Demographic Data and Computer Usage Characteristics of the Respondents

	Gender (1-male, 2-female)*	**Age** (years)	**Computer Experience** (years)	**Computer Use per day** (hours)	**VR App/ Game Usage** (1-5)**	**E-Commerce Shopping Exp.** (1-yes, 2-no)*
Median	2.00	20.00	9.00	5.00	3.00	1.00
Std. Deviation	.45	1.05	2.58	3.00	1.12	.35

*Items are categorical dichotomous values

**Virtual Reality/Game Usage is ordinal: 1-never, 2-rarely (less than once a month), 3-occasionally (at least once a month), 4-frequently (at least once a week), 5-everyday

Before the splitting of the data, normal Q-Q plots were drawn and analyzed to make sure that the data distributed normally and the extreme cases were eliminated. After the cases were split, it was important that the divided groups were comparable or homogenous to minimize third variable effects. It can be done by applying the independent sample t-test across the divided groups on factors studying for moderating effects. The results of the t-test across gender groups suggested that VR

application/game usage characteristic between the male and female group was not homogenous; males use VR application/game significantly more frequently than females. The data had to be adjusted since if VR application/game usage characteristic of users played a significant role on users' preference on importance of interface quality factors, it would interfere with the analysis on gender as a moderator. In this case, female cases with low usage of VR application/game will be eliminated, five cases at a time, to raise the mean of the female group until both groups were homogenous. The female group was manipulated since it had higher number of cases. This iterating process was performed until the split groups by any expected moderators were homogenous.

Table 3 – Independent Sample t-test on the Demographics and Computer Usage Characteristics across Gender Groups

		Levene's Test		**t-test for Equality of Means**						
	Equal Variance Assumed	**F**	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Diff.**	**Std. Error Diff.**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
Age	Yes	3.005	.085	.974	142	.332	.09022	.09259	-.09281	.27325
	No			.978	74.097	.331	.09022	.09230	-.09368	.27412
Computer Experience	Yes	.939	.334	.441	140	.660	.04081	.09259	-.14224	.22387
	No			.441	74.409	.660	.04081	.09246	-.14339	.22502
Computer Usage per Day	Yes	1.121	.292	-1.260	132	.210	-.12007	.09529	-.30856	.06843
	No			-1.247	66.463	.217	-.12007	.09632	-.31235	.07221
VR App/Game Usage	Yes	133.536	.000	4.326	141	.000	.36824	.08513	.19996	.53653
	No			5.131	110.671	.000	.36824	.07177	.22602	.51047
E-Commerce Shopping Exp.	Yes	.056	.813	.119	140	.905	.008	.065	-.121	.136
	No			.118	72.209	.907	.008	.066	-.123	.139

There were 95 cases left for the next stage of analysis. The final split datasets are summarized in Table 4. Table 5 shows descriptive statistics of the final demographic data and computer usage characteristics of the respondents, which were used in the next stage of analysis, after the data was adjusted for homogeneity. It has to be noted that gender and e-commerce shopping experience are categorical variables, and

VR application/game usage is an ordinal variable, so their arithmetic means should not be calculated. The values are shown to provide a rough proportion of the data. The distributions of the final data used for moderation analysis are provided in Figure 2, 3, 4, 5, 6 and 7.

Table 5 – Summary of Split Datasets

No.	Group	Number of Cases	
		Group 1/Low Group	**Group 2/High Group**
1	Gender (1-male, 2-female)	41	54
2	Age	42	53
3	Computer Usage Experience	37	58
4	Computer Usage per Day	42	53
5	VR Application/Game Usage	19	76
6	E-Commerce Shopping Experience (1-yes, 2-no)	82	13

Table 4 – Descriptive Statistics of the Final Demographic Data and Computer Usage Characteristics of the Respondents used in the Analysis

	Gender (1-male, 2-female)*	**Age** (years)	**Computer Experience** (years)	**Computer Use per day** (hours)	**VR App/ Game Usage** (1-5)**	**E-Commerce Shopping Exp.** (1-yes, 2-no)*
Means	1.57	19.88	9.00	5.58	3.21	1.14
Std. Deviation	.50	1.05	2.41	3.14	1.04	.35

*Gender and E-Commerce Shopping Experience are categorical dichotomous values

**Virtual Reality/Game Usage is ordinal: 1-never, 2-rarely (less than once a month), 3-occasionally (at least once a month), 4-frequently (at least once a week), 5-everyday

Figure 2 – Frequency distribution of final demographics and computer usage characteristics: (a) gender, (b) age, (c) computer usage experience, (d) computer usage per day, (e) VR application/game usage and (f) e-commerce shopping experience

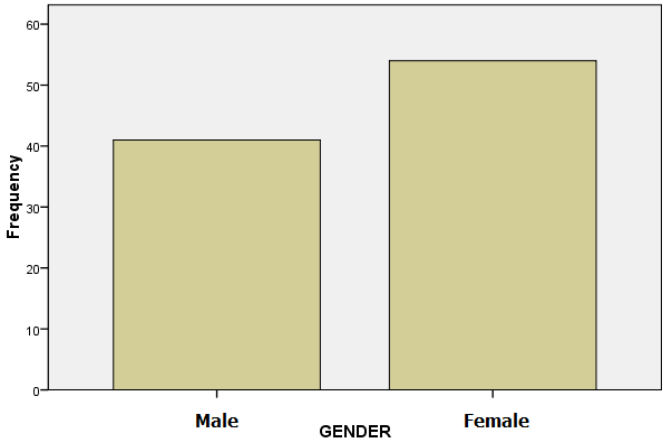

Figure 2 (a)

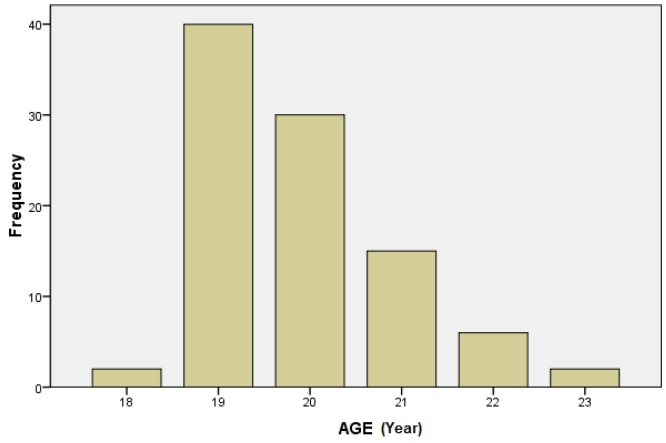

Figure 2 (b)

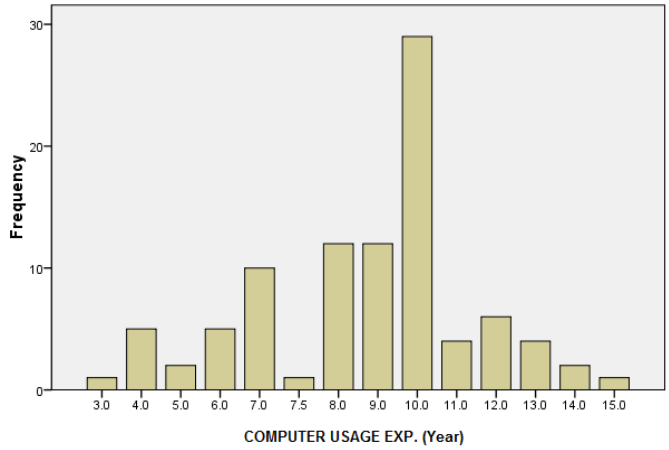

Figure 2 (c)

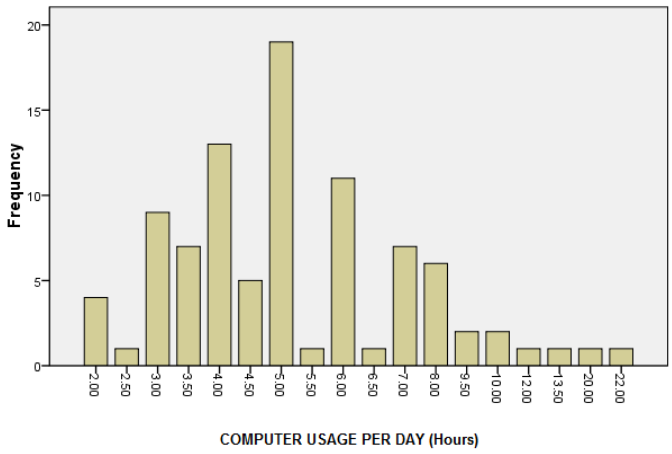

Figure 2 (d)

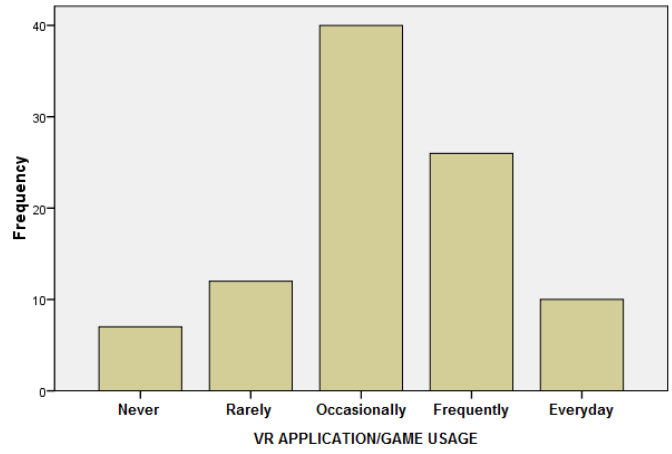

Figure 2 (e)

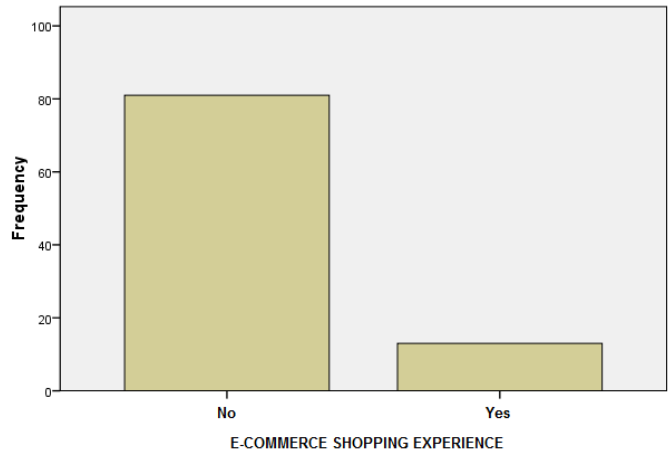

Figure 2 (f)

Next, a series of the independent-sample t-test was applied to compare means of importance ratings of VR interface quality factor between split groups of each tested moderators. Full results of the t-test analyses are provided in the Appendix. The results suggested that there is only one factor confirmed as a moderator, which is gender as a moderator on users' importance rating of content finding (t_{93}=2.00, p<0.05), captured and presented in Table 6. However, age and computer usage experience tend to exhibit their moderating effects as well with t_{93}=1.98 (p>0.05) and t_{92}=1.91 (p>0.05) respectively.

Table 6

		Levene's Test for Equality of Variances		t-test for Equality of Means						
	Equal variances assumed	F	Sig.	t	df	Sig.(2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
									Lower	Upper
Content Finding across Gender Groups	Yes	.026	.871	2.006	93	.048	.34824	.17360	.00350	.69298
	No			2.056	92.133	.043	.34824	.16935	.01191	.68457
Content Finding across Age Groups	Yes	.000	.991	1.976	93	.051	.34232	.17324	-.00171	.68634
	No			1.978	88.418	.051	.34232	.17308	-.00161	.68625
Standard Appearance across Computer Exp.	Yes	.777	.380	1.909	92	.059	.24585	.12876	-.00987	.50157
	No			2.008	85.780	.048	.24585	.12243	.00245	.48924

Male users tend to prefer the product finding mechanism rather than female. Further investigation on the cause of this can be done by future study or comparable relations in literatures to understand the phenomena. Female might enjoy browsing the VR world like they tend to enjoy go out for shopping while male might not enjoy window shopping that much and would like to grab the items as soon as he can.

A range of Practical implications of this could be outlined. Building a VR store is considered more expensive than generic e-commerce stores, thus providing a personalized store to achieve individual user satisfaction and sales transaction should be implemented effectively. It can be referred from the results regarding the moderating effect of gender on content finding factor that a VR store can provide a more obvious searching feature and, probably, more extensive search criteria for male

customers. Mechanism for male customers to more easily reach items they frequently use or on the current demand should be considered. This might include easy-to-reach product placement, product displayed, advertisement while searching for instances. While for female customers, more product promotion and advertisement are appropriate to offer along the corridor of the VR store as they would like to browse around the store rather than directly searching for merchandise.

Although the rest of the users' demographics and computer usage characteristics did not significant moderate the preference on the importance of each interface quality factor, couple of users' characteristics tend to exhibit moderating effects. Younger users tend to prefer a product finding feature more than that of older users. Moreover, proper use of colors, fonts and store layout customization in the interface quality factor of standard appearance were more preferred as higher important features by users with lower computer usage experience than they were preferred by users with higher computer usage experience. The mention strategies can also be implemented for users between the age groups since age also tend to moderate the importance rating of content finding feature. However, further study is needed to understand the range of the users' age that more prefer product searching features or the VR store can provide an option or learning mechanism to adjust the interface behavior to suit each customer. Users who tend to use searching feature should be offered more support or promotion activity during searching. In case of the last moderating effect tendency, computer usage experience on standard appearance, the VR store can allow users to choose their own preference of colors, fonts and store layouts.

Other users' demographics and computer usage characteristics: computer usage per day, VR store application/game usage and e-commerce shopping experience, did not play significant roles to differentiate users' preferences on the VR store interface. It should keep in mind that further repeated studies with similar findings are needed to hold the claim on the relationships of users' characteristics toward preferences on importance of the early explored VR interface quality factors. The reasons for why the differences of these users' characteristics did not significantly alter their preferences could be that the range of the samples might narrow. Future study should be conducted to represent targeted population of VR store and e-commerce

users. If the findings are repeatedly confirmed, the theoretical contributions will ease future studies on the area regarding that the heterogeneity of samples play minor roles on their interface preferences.

5. Conclusion and Future Works

This study was conducted to determine interface preferences of different groups of users by studying moderating effects of demographics and computer usage characteristics of users as moderators on importance of quality factors for VR interface. Based on the data collected from 144 IT undergraduate students in a university located in the northeastern of Thailand, we can conclude that. There was only one moderator, gender, affecting the importance preference of VR interface quality factor, content finding. Male users tend to look for particular products directly. Female users might enjoy wandering around the VR commerce store instead of jumping directly to the product, which can be a future study. Most of the demographic data and computer usage characteristics of users did not moderate the preference of interface quality factor importance. The finding can be utilized as guidelines for developing and personalizing a better quality online VR commerce interface. The study is also mandatory and contributes to the future study of preferable VR interface design, especially to the research design and methodology regarding moderating effects of users' differences. Moreover, the work can be advanced to contribute further in developing a reliable instrument to evaluate this rich interface. Future studies can expand to cover other types of VR interface and the generalization of VR interface quality and usability.

ACKNOWLEDGMENTS

We appreciate energetic participants and respondents, undergraduate students from Suranaree University of Technology, Nakhon Ratchasima, Thailand, who contributed to the first and the second stage of the study.

REFERENCES

Aladwani, A. M. & Palvia, P. C. 2002. Developing and validating an instruement for measuring user-perceived web quality. *Information & Management*, 39(467-476).

Biocca, F. 1997. Cyborg's Dilemma: Progressive Embodiment in Virtual Environments. *Journal of Computer Mediated-Communication*, 3(2).

Boulos, M. N. K., Hetherington, L., & Wheeler, S. 2007. Second Life: an overview of the potential of 3-D virtual worlds in medical and health education. *Health Information & Libraries Journal*, 24(4): 233-245.

Burdea, G. C. & Coiffet, P. 2003. *Virtual Reality Technology* (2nd ed.). Boston: MIT Press.

Bureau of The Royal Household; Thai Royal Palaces Virtual Tour; http://www.palaces.thai.net/vt/vtgp/; June, 10, 2010.

Daft, R., Lengel, R., & Trevino, L. 1987. Message equivocality, media selection, and manager performance:Implications for information systems. *MIS Quarterly*, 17: 355-366.

Jahng, J., Jain, H. K., & Ramamurthy, K. 2006. An Empirical Study of the Impact of Product Characteristics and Electronic Commerce Interface Richness on Consumer Attitude and Purchase Intentions. *IEEE Transactions on Systems, Man and Cybernetics—Part A: Systems and Humans*, 36(6): 1185-1201.

Klein, L. R.; Creating Virtual Experience; http://www.ruf.rice.edu/~lklein/papers/VirtualExperiences0801.pdf; Dec 5, 2009.

Koyani, S. J., Bailey, R. W., Nall, J. R., Allison, S., Mulligan, C., Bailey, K., & Tolson, M.; Research - based web design and usability guidelines; http://usability.gov/guidelines/guidelines_book.pdf.

Lepouras, G. & Vassilakis, C. 2006. An adaptive virtual reality architecture for shopping malls. , *Encyclopedia of E-Commerce, E-Government and Mobile Commerce*. USA: Idea Group Publishing Hershey.

Li, H., Daugherty, T., & Biocca, F. 2003. The Role of Virtual Experience in Consumer Learning. *Journal of Consumer Psychology* 13(4): 395-408.

Linden Research, Inc.; Second Life; http://secondlife.com; June 10, 2010.

Lu, Y. & Smith, S. 2007. Augmented Reality E-Commerce Assistant System: Trying While Shopping, *Lecture Notes in Computer Science (LNCS)*, Vol. 2007: 643-652: Springer Berlin / Heidelberg.

Najihah , M. Z. 2009. *Virtual Reality Features for E-Commerce 3D PDF Advertising.* . Unpublished Masters Thesis, Universiti Utara Malaysia.

Phosaard, S. & Tanthanuch, J. 2007. PakPao 3D: The Design and Implementation of a Three-Dimensional User Interface for an Operating System Using a Game Engine. *Proceedings of the World Congress on Engineering, WCE2007*, London, U.K.

Phosaard, S. & Rattanawicha, P. 2010. Quality Factors for Online Virtual Reality Commerce Interface. *Proceedings of the International Conference on IT Application and Management (ITAM-IV2010)*, Bangkok.

Pimentel, K. & Teixeira, K. 1994. *Virtual Reality: Through the New Looking Glass* (2nd ed.). New York: Intel/McGraw-Hill.

Seymour, N. E., Gallagher, A. G., Roman, S. A., O'Brien, M. K., Bansal, V. K., Andersen, D. K., & Satava, R. M. 2002. Virtual Reality Training Improves

Operating Room Performance. *Annals of Surgery*, 236(4): 458-464.

Steuer, J. 1992. Defining Virtual Reality: Dimensions Determining Telepresence. *Journal of Communication*, 42(4): 73-93.

Suh, K.-S. & Lee, Y. E. 2005. The Effects of Virtual Reality on Consumer Learning: An Empirical Investigation. *MIS Quarterly*, 29(4): 673-695.

U.S. Department of Commerce. 2009. Quarterly Retail E-Commerce Sales, *U.S. Census Bureau News*, Vol. 1st Quarter 2009.

APPENDIX

Table A1 – Testing of Moderating Effects of Users' Gender on Quality Factors for VR Commerce Interface by Independent Sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Basic VR Experience	Equal variances assumed	.004	.951	-.021	93	.984	-.00301	.14611	-.29315	.28713
	Equal variances not assumed			-.020	84.250	.984	-.00301	.14699	-.29531	.28928
Aspect Fit	Equal variances assumed	.466	.497	.670	93	.504	.09192	.13710	-.18034	.36417
	Equal variances not assumed			.662	81.694	.510	.09192	.13891	-.18443	.36826
Acceleration Capability	Equal variances assumed	.036	.850	-.468	92	.641	-.07432	.15878	-.38968	.24103
	Equal variances not assumed			-.463	82.064	.645	-.07432	.16062	-.39385	.24521
Standard Appearance	Equal variances assumed	.250	.619	.368	93	.714	.04712	.12817	-.20739	.30164
	Equal variances not assumed			.364	82.644	.717	.04712	.12953	-.21051	.30476
Atmospheric Experience	Equal variances assumed	1.104	.296	-1.798	93	.075	-.24526	.13644	-.51619	.02568
	Equal variances not assumed			-1.745	75.144	.085	-.24526	.14058	-.52530	.03478
Decorative Element	Equal variances assumed	5.443	.022	-.033	92	.974	-.00494	.14964	-.30214	.29226
	Equal variances not assumed			-.032	69.180	.975	-.00494	.15619	-.31651	.30663
Place Familiarity	Equal variances assumed	.001	.981	.219	93	.827	.03975	.18150	-.32067	.40016
	Equal variances not assumed			.220	88.286	.826	.03975	.18028	-.31851	.39801
Content Finding	Equal variances assumed	.026	.871	2.006	93	.048	.34824	.17360	.00350	.69298
	Equal variances not assumed			2.056	92.133	.043	.34824	.16935	.01191	.68457

Table A2 – Testing of Moderating Effects of Users' Age on Quality Factors for VR Commerce Interface by Independent Sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Basic VR Experience	Equal variances assumed	.559	.456	-.582	93	.562	-.08461	.14545	-.37344	.20423
	Equal variances not assumed			-.578	85.811	.565	-.08461	.14638	-.37561	.20640
Aspect Fit	Equal variances assumed	.003	.956	.433	93	.666	.05930	.13692	-.21260	.33120
	Equal variances not assumed			.434	88.930	.665	.05930	.13657	-.21207	.33067
Acceleration Capability	Equal variances assumed	2.732	.102	.075	92	.940	.01190	.15857	-.30302	.32683
	Equal variances not assumed			.073	74.134	.942	.01190	.16349	-.31385	.33766
Standard Appearance	Equal variances assumed	.020	.887	.818	93	.416	.10422	.12746	-.14888	.35733
	Equal variances not assumed			.819	88.429	.415	.10422	.12733	-.14881	.35725
Atmospheric Experience	Equal variances assumed	7.329	.008	1.174	93	.243	.16128	.13740	-.11157	.43412
	Equal variances not assumed			1.223	91.429	.224	.16128	.13182	-.10055	.42310
Decorative Element	Equal variances assumed	.563	.455	-.189	92	.851	-.02808	.14879	-.32359	.26742
	Equal variances not assumed			-.188	86.748	.851	-.02808	.14927	-.32478	.26862
Place Familiarity	Equal variances assumed	3.268	.074	-1.633	93	.106	-.29155	.17851	-.64604	.06293
	Equal variances not assumed			-1.590	76.990	.116	-.29155	.18333	-.65661	.07350
Content Finding	Equal variances assumed	.000	.991	1.976	93	.051	.34232	.17324	-.00171	.68634
	Equal variances not assumed			1.978	88.418	.051	.34232	.17308	-.00161	.68625

Table A3 – Testing of Moderating Effects of Users' Computer Usage Experience on Quality Factor for VR Commerce Interface by Independent Sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Basic VR Experience	Equal variances assumed	2.012	.159	.859	92	.393	.12867	.14986	-.16896	.42630
	Equal variances not assumed			.932	90.668	.354	.12867	.13808	-.14561	.40296
Aspect Fit	Equal variances assumed	.016	.900	.543	92	.589	.07615	.14033	-.20256	.35486
	Equal variances not assumed			.547	76.228	.586	.07615	.13924	-.20115	.35345
Acceleration Capability	Equal variances assumed	2.434	.122	1.354	91	.179	.22044	.16286	-.10306	.54395
	Equal variances not assumed			1.451	86.522	.150	.22044	.15193	-.08156	.52244
Standard Appearance	Equal variances assumed	.777	.380	1.909	92	.059	.24585	.12876	-.00987	.50157
	Equal variances not assumed			2.008	85.780	.048	.24585	.12243	.00245	.48924
Atmospheric Experience	Equal variances assumed	.630	.429	.888	92	.377	.12644	.14232	-.15622	.40910
	Equal variances not assumed			.926	83.864	.357	.12644	.13660	-.14522	.39809
Decorative Element	Equal variances assumed	.127	.722	1.511	91	.134	.22904	.15157	-.07203	.53012
	Equal variances not assumed			1.568	83.181	.121	.22904	.14611	-.06155	.51964
Place Familiarity	Equal variances assumed	.049	.826	1.665	92	.099	.30651	.18413	-.05919	.67221
	Equal variances not assumed			1.689	77.819	.095	.30651	.18148	-.05481	.66783
Content Finding	Equal variances assumed	.001	.975	1.639	92	.105	.29502	.17999	-.06246	.65250
	Equal variances not assumed			1.691	81.665	.095	.29502	.17450	-.05213	.64217

Table A4 – Testing of Moderating Effects of Users' Computer Usage per Day on Quality Factors for VR Commerce Interface by Independent Sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Basic VR Experience	Equal variances assumed	2.166	.145	-.595	90	.554	-.08870	.14919	-.38509	.20770
	Equal variances not assumed			-.572	68.827	.569	-.08870	.15518	-.39828	.22089
Aspect Fit	Equal variances assumed	.935	.336	.921	90	.360	.12845	.13951	-.14871	.40561
	Equal variances not assumed			.942	87.752	.349	.12845	.13633	-.14250	.39939
Acceleration Capability	Equal variances assumed	.014	.907	-.217	89	.828	-.03526	.16226	-.35766	.28715
	Equal variances not assumed			-.213	76.141	.832	-.03526	.16515	-.36417	.29366
Standard Appearance	Equal variances assumed	.003	.957	-.734	90	.465	-.09579	.13046	-.35498	.16340
	Equal variances not assumed			-.736	82.601	.464	-.09579	.13022	-.35480	.16322
Atmospheric Experience	Equal variances assumed	.344	.559	-.469	90	.640	-.06676	.14244	-.34974	.21621
	Equal variances not assumed			-.466	80.281	.642	-.06676	.14325	-.35183	.21830
Decorative Element	Equal variances assumed	.608	.438	-.298	89	.766	-.04487	.15062	-.34415	.25441
	Equal variances not assumed			-.293	76.300	.770	-.04487	.15324	-.35005	.26030
Place Familiarity	Equal variances assumed	.463	.498	.440	90	.661	.08128	.18485	-.28595	.44851
	Equal variances not assumed			.435	79.008	.664	.08128	.18664	-.29022	.45278
Content Finding	Equal variances assumed	.733	.394	.747	90	.457	.13498	.18074	-.22410	.49406
	Equal variances not assumed			.736	77.244	.464	.13498	.18347	-.23034	.50030

Table A5 – Testing of Moderating Effects of User's Virtual Reality Application/Game Usage on Quality Factors for VR Commerce Interface by Independent Sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Meanf Difference	Std. Error Difference	Lower	Upper
Basic VR Experience	Equal variances assumed	.009	.926	-.364	93	.717	-.06579	.18079	-.42480	.29322
	Equal variances not assumed			-.360	27.379	.721	-.06579	.18260	-.44020	.30862
Aspect Fit	Equal variances assumed	3.332	.071	-.309	93	.758	-.05263	.17009	-.39039	.28513
	Equal variances not assumed			-.360	34.640	.721	-.05263	.14612	-.34938	.24412
Acceleration Capability	Equal variances assumed	.125	.725	.134	92	.894	.02632	.19629	-.36353	.41617
	Equal variances not assumed			.146	31.453	.884	.02632	.17967	-.33992	.39255
Standard Appearance	Equal variances assumed	4.780	.031	.083	93	.934	.01316	.15881	-.30221	.32853
	Equal variances not assumed			.094	33.028	.926	.01316	.14033	-.27233	.29865
Atmospheric Experience	Equal variances assumed	.081	.776	-.134	93	.894	-.02303	.17183	-.36425	.31820
	Equal variances not assumed			-.126	25.894	.900	-.02303	.18235	-.39794	.35188
Decorative Element	Equal variances assumed	1.714	.194	-.103	92	.918	-.01895	.18422	-.38483	.34694
	Equal variances not assumed			-.087	23.438	.931	-.01895	.21784	-.46912	.43123
Place Familiarity	Equal variances assumed	.352	.555	-.704	93	.483	-.15789	.22420	-.60310	.28731
	Equal variances not assumed			-.692	27.120	.495	-.15789	.22826	-.62615	.31036
Content Finding	Equal variances assumed	.985	.324	-1.147	93	.254	-.25000	.21803	-.68296	.18296
	Equal variances not assumed			-1.064	25.486	.297	-.25000	.23492	-.73336	.23336

Table A6 – Testing of Moderating Effects of Users' Ecommerce Shopping Experience on Quality Factors for VR Commerce Interface by Independent Sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Basic VR Experience	Equal variances assumed	.708	.402	-1.075	92	.285	-.22602	.21016	-.64341	.19137
	Equal variances not assumed			-1.412	21.308	.172	-.22602	.16010	-.55867	.10663
Aspect Fit	Equal variances assumed	.613	.436	-.112	92	.911	-.02232	.19914	-.41782	.37319
	Equal variances not assumed			-.101	15.032	.921	-.02232	.22112	-.49354	.44891
Acceleration Capability	Equal variances assumed	.414	.522	-.557	91	.579	-.12788	.22943	-.58361	.32784
	Equal variances not assumed			-.593	16.980	.561	-.12788	.21557	-.58273	.32696
Standard Appearance	Equal variances assumed	.001	.977	-.226	92	.821	-.04210	.18595	-.41142	.32722
	Equal variances not assumed			-.233	16.473	.818	-.04210	.18043	-.42371	.33950
Atmospheric Experience	Equal variances assumed	.054	.817	-1.006	92	.317	-.20085	.19957	-.59722	.19551
	Equal variances not assumed			-1.042	16.537	.312	-.20085	.19270	-.60828	.20657
Decorative Element	Equal variances assumed	.139	.710	-1.389	91	.168	-.29647	.21341	-.72038	.12743
	Equal variances not assumed			-1.369	15.982	.190	-.29647	.21651	-.75549	.16255
Place Familiarity	Equal variances assumed	6.748	.011	-.231	92	.818	-.06078	.26308	-.58329	.46173
	Equal variances not assumed			-.327	23.923	.747	-.06078	.18598	-.44468	.32313
Content Finding	Equal variances assumed	.784	.378	.387	92	.700	.09877	.25537	-.40842	.60596
	Equal variances not assumed			.366	15.489	.720	.09877	.27006	-.47527	.67280