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The Study on the Application in the Combination of Pervasive Gaming and Augmented Reality in the Temple Tour for Users with Different Cognitive Styles

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Abstract: As time goes by, the temple culture is fading away along with the loss of senior and aging temple managers. It's worth discussing how to prolong the cultural property and to stretch the stories that have been passed down from generation to generation. In Taiwan, using mobile device to assist visitors to know better in the temple tour has been applied for years by many well-known temples, however, other small temples contain the obscure but essential culture that completes the atlas of religious affiliation not only as the centers of religion but also of education, civil culture, fine arts, sightseeing and humanities. The technology of PG and AR on mobile devices with the digital tour guides introduces the name, history and story about the trigger images. Through the guidance for each mission, users can feel secured and achieve "studying by playing". This study emphasizes on the different learning performances of the students with diverse cognitive styles, and also innovates teaching models by PG. The aim of this study was to obtain qualitative and quantitative data from all 60 participants, with no limit to any age, gender or educational status, by parallel value from both types of data evaluation through the pre- and post-learning performance scale, SOP, SUS and focus group interviews. The result shows (1) PG in the ARTTS was evaluated to be highly satisfying. (2) There was no significant difference between participants with different cognitive styles in use of the system. (3) There was no difference in the learning performance of the participants with different cognitive styles. (4) The learning performance was more effective by the Temple Tour System than printed brochures. (5) The learning performance by the Temple Tour System from all cognitive styles was higher. The study makes 3 suggestions to the future researches, the temple architecture can be added into the introduction, the AR system can be triggered into the pictures rendered in 3D for the more innovative experience, and the customized tour systems for any ages that provide service to the families with children for the better experience and knowledge during the temple tour.

Keywords: Augmented Reality, Pervasive Gaming, temple culture, cognitive style, temple tour

1. Introduction

While the clock ticked, the temple culture was lapsing year-by-year due to the vanishing of temple managers. The aim of this study is to discuss how to perpetuate the cultural value and to conserve the legends made by every generation. Traditionally, visitors explore highlights of the temples through a variety of tours led by temple-trained managers or volunteers with printed brochures, which usually become some flat souvenirs but nothing more. Meanwhile, the management may have difficulties in human resources for guided tours. As a result, the visitors would undergo struggles for inquiring the needed information. For energy conservation and cost reduction, the mobile digital tour systems have been developed and widely installed on tablets and smartphones. There are many famous temples in Taiwan using mobile devices to help visitors navigate and learn about the interesting features, in the meantime, other temples still embrace the noteworthy culture. For the above reasons, this study

developed PG missions in ARTTS for Lee Xin Fu De Temple (2, Ln. 162, Yuantong Rd., Zhonghe Dist., New Taipei City, Taiwan). This innovative teaching aid provides learning and navigation covered by PG and guided missions.

The study considers whether objectives and research questions as followed:

- How can PG develop to be applied to ARTTS for visitors to inquire information?
- How do the participants feel after using ARTTS?
- How do the participants with diverse cognitive styles feel after using ARTTS?
- Are learning performances diversified after various touring programs?
- Are learning performances diversified between participants with diverse cognitive styles
- Is the interaction varied between cognitive styles and touring programs?

2. Literature review

2.1. Augmented Reality

This study defines Augmented Reality (AR) as a real-time view of a physical environment which has been amplified/augmented by the add-on virtual objects and information to it. Researchers Milgram,Takemura, Utsumi and Kishino (1994) have noted that reality-virtual continuum (see Figure 1.) considers Real Environment and Virtual Environment as opposite ends comprising AR and Augmented Virtuality (AV) in between. Chen C. (2015) considers AR as an extinct and augmented environment from Virtual Reality (VR) which replaces the physical world by 3D sceneries. AR technology enriches the real-world environment with the needed digital information and guiding media, such as 3D models and parallel videos, overlaying in the real-time camera view of users' smartphone, tablet, computers or smartglasses.

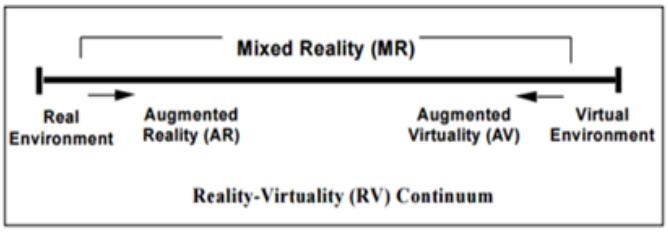

Figure 1. Reality-Virtual (RV) Continuum.

Augmented Reality (AR) has received higher overall evaluation in the potential and innovative application to education, medication, fine arts, amusement and recreation, as well as the training courses for medicine/surgery/anatomy, military/police, disaster escape/prevention, manufacturing/fabrication/repair/operation, etc. The extra use of AR provides more creative learning environment to strengthen relationships among users, physical world and virtual scenery. Enhancing users' knowledge, memorization and learning performance, AR boosts up the process of comprehension, motivation, participation and enthusiasm of them in the meantime.

2.2. Pervasive Gaming

Mobile gaming has roared onto smartphones and tablets as the cellular mainstream, while Pervasive Gaming (PG) brings the adventure away from computer screens and back to the three-dimensional world (Montola, 2009). PG as one of the rising forms combines the real-world positioning technology and virtual gamespace into the mobile interactive game, and it represents a commercially promising type of mobile games that builds upon a combination of hybrid interfaces, wireless networking, and context-sensing technology (Benford, Magerkurth & Ljungstrand, 2005). Researcher Hsu X. (2011) has noted that PG blends up physical and virtual sceneries, and emphasizes more, than Virtual Reality

(VR) gaming does, on the gaming process of the interaction between users and real-world environment.

The main theme of this study is Pervasive Gaming (PG) in Temple Tour containing the guided PG missions about the history, stories of the gods, mythological weapons, etc. Began on the mission of history, the visitors as users of Augmented Reality Temple Tour System (ARTTS) are sequentially guided through each missions to the final destination for real-world expedition of learning-by-playing.

2.3. Cognitive Style

Cognitive style is a term used in cognitive psychology to describe the way of individuals' typical mode to think, perceive, remember and processing information for problem-solving. Cognitive style differs from cognitive ability of the individuals in the development of learning. The hypotheses of cognitive styles has been widely discussed and studied, still, there is controversy over the explicit meaning of the term "cognitive style" and whether it is a single or multiple aspect of human personality. Definitions from scholars and researchers (See Table 1.) improve our understanding and learning.

Table 1. Definitions of Cognitive Style from different scholars

Scholars & Researchers	Year	Definitions of Cognitive Style
Messick	1976	the individual's typical mode to either process information, think, memorize or solve problems.
K.Y. Yang	1996	the preference of learner to process the received information
R. J. Riding & Rayner	1998	an individual's consistent approach to organising and processing information during thinking
Y. J. Lin	2013	an individual's different mode and preference to process new external stimulation
J. Cheng	2014	an individual's personal characteristic to construct and process learning status on external information and environment

3. Research Design

3.1. Pervasive Gaming in Augmented Reality Temple Tour System

Augmented Reality Temple Tour system (ARTTS) was developed on Unity, including Vuforia Software Development Kit (SDK) as the main kit for Augmented Reality (AR). Began on "A new temple host" (see Figure 2.) as the introduction, Pervasive Gaming (PG) in ARTTS contains 4 levels, Visiting Route, Constructing History, Almighty Power of God, and Mythological Weapons. The contents of the missions above as followed, Visiting Route provides directions for the better touring experience, Constructing History brings back what had been contributed in the past, Almighty Power of God shows the mythological strength and legend, and Mythological Weapons demonstrate the fascinating power.

Augmented Reality Temple Tour system (ARTTS) is designed with a linear plot begins at a certain point, moves through 4 missions and then ends up at the other point. Take Almighty Power of God for instance, users begin the mission with Temple Primary School (see Figure 4.) and learn about the facts and basic information about the god of this section. Then, The rules of this mission (see Figure 5.) will come up for visitors to follow and complete it. Finally, the God of Land will

appear to interact with the participants (see Figure 6.), and a pop quiz will close up the mission by examining what the visitors have learned and comprehended (see Figure 7 & 8.).

Figure 2. Introduction.

Figure 3. Mission Entry. Figure 4. Temple Primary School. Figure 5. Mission Prompt.

Figure 6. AR Interaction. Figure 7. Pop Quiz. Figure 8. Answer and Explanation.

4. Research Tool

4.1. Style of Processing (SOP) Scale

In order to access the cognitive style, this study adapted the *Style of Processing (SOP) Scale* constructed by Childers et al. (1985) and modified by Wang C. (2008) from 22 into 20 questions and other semantic adjustments. Visualizer/verbaliser dimension is one of the most widely discussed cognitive style dimensions. Some individuals prefer to process the received information verbally, while others like to form mental images (Childers et al. 1985). Visualizers scored higher than the average of all participants, whereas verbalisers scored less. Visualizers are those individuals whose tendency is mainly on imagery processes when performing cognitive tasks; verbalizers prefer to process information by verbal-logical means (Kozhevnikov, 2002).

4.2. System Usability Scale (SUS)

The system usability scale (SUS) is adapted as a simple and reliable tool for measuring and engineering the system. SUS was created by John Brooke in 1986, and it consists of a ten-item attitude Likert scale for respondents ; from Strongly agree to Strongly disagree, giving a global view of subjective assessments of usability. Meanwhile, cross-interrogation has been arranged to evaluate the interactive objective and the better concentration of the respondents.

4.3. Pre-and Post- Learning Performance Scale

To evaluate how do the participants change their knowledge of the temple, this research develops the learning content through touring, based on the information from all the Chinese Old Farmer's Almanacs that Lee Xin Fu De Temple has printed and provided for visitors. This study also designs Pre-and Post- Learning Performance Scale with content validity, and it only changes the order of questions and options from pre-to-post. There are 25 questions in total, 30 minutes for respondents to answer, and a compound format of 4 question types including true/false, multiple-choice, matching item and connect-the-dots.

4.4. Experiment Process

This study aims to explore the usability and learning efficiency of Pervasive Gaming (PG) in Augmented Reality Temple Tour System (ARTTS). Its subjects are mainly pilgrims, and the touring location is Lee Xin Fu De Temple (Zhonghe Dist., New Taipei City, Taiwan). There are 4 learning units as Visiting Route, Constructing History, Almighty Power of God, and Mythological Weapons. The research process flowchart (see *Figure 9.*) shows that the Control Group received traditional touring format composed of printed brochures and trained staffs during 40 minutes of learning. Experimental group will receive PG in ARTTS as participants, learning through playing tasks and completing missions on mobile devices during 40 minutes and afterwards close upon learning efficiency questionnaire as respondents for 10 minutes. The aim of this study focused on engineering ARTTS for providing the better assistance to visitors and pilgrims to temples in Taiwan, a case study of Lee Xin Fu De Temple. Finally, a focus group meeting will be conducted for experiment analysis to enhance the accessibility of information and the balance of cognitive styles.

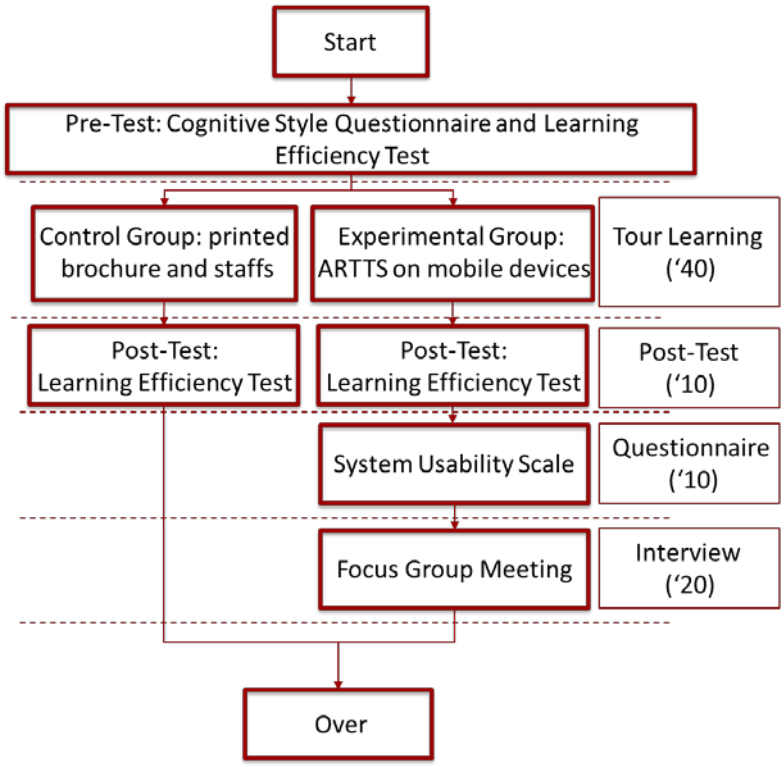

Figure 9. The Research Process Flowchart.

5. Results

5.1. Cognitive Style

In this study, 60 questionnaires had been issued to each of 60 participants, and we collected 58 valid samples, and 2 removed invalid samples. After analysis, Mean is 74.32, and Standard Deviation is 9.636. Verbalizers are the participants under 71, and visualizers are the participants above 78. In the traditional Control Group, the number of verbalizers is 8 and visualizers 13. In the ARTTS Experimental Group, the number of verbalizers is 12 and visualizers 14. Table 2. shows the cognitive style distribution of the participants.

Table 2. the cognitive style distribution of the participants

Group	Visualizer	Verbalizer	Neutral	Counts	M+1/3D	M-1/3D
Control	13	8	7	29	77.539	71.115
Experimental	14	12	4	29		
SUM	27	20	11	58		

5.2. System Usability Scale (SUS)

After being transferred, the data (see Table 3.) shows the calculation of SUS, Mean is 85.19, Median is 90, Maximum Number is 97.5, Minimum Number is 42.5, and Standard Deviation is 13.53.

Table 3. the calculation of SUS

	Sample	Average	Median	Max.	Min.	Std Dev

	Number					
Value	29	85.19	90	97.5	42.5	13.53

5.3. Comparison of diverse Cognitive Styles in SUS

Table 4. shows the ANOVA analysis that Mean of Verbalizers is 81.88 and Visualizers 88.04 of the participants in Experimental Group. Hence, SUS of Visualizers is higher than the other with the significance .056>.05. As a result. there is no significant difference between these 2 cognitive styles.

Table 4. the ANOVA analysis

	Style	Value	Average	Std Dev	Std Err.	Significance
SUS	Verbalizer	12	81.88	18.157	5.242	0.056
	Visualizer	14	88.04	9.617	2.570	
	SUM	26	85.19	14.246	2.794	

5.4. Analysis of Pre-and Post- Test

Table 5. (see below) shows the significance of Experimental Group is 0.444 < 0.05 and the significance of traditional Control Group is 0.351 < 0.05, there are no significant difference in both groups. Table 6. (see below) shows that T-test on independent samples finds no significant difference in both groups with the significance as 0.678 > 0.05, indicating the participants are not acquainted with the temple nor have pre-knowledge.

Table 5. The T-test on Independent Samples on Pre-test Learning Performance of Diverse Cognitive Styles of Participants

Pre-test Learning Performance Scale	Cognitive Style	Value	Average	Std Dev	Average of Std Dev	T-test	
						t	Significance
Experimental Group	Visualizer	12	47.67	13.48	3.891	.778	.444
	Verbalizer	14	52	14.718	3.934		
Control Group	Visualizer	8	43.00	18.486	6.536	.956	.351
	Verbalizer	13	51.08	18.984	5.265		

Table 6. the T-test on Independent Samples on Pre-test Learning Performance of Diverse Touring Types

Pre-test Learning Performance Scale	N	Average	Std Dev	Average of Std Dev	T-test	
					t	Significance
Experimental Group	26	50	14.051	2.756	.418	0.678

Control Group	21	48	18.762	4.094		

5.5. Difference in diverse cognitive styles of participants

By the analysis of both cognitive styles of Verbalizers and Visualizers, the post-test average of the learning performance of Verbalizers is 85.4, the average of the learning performance of Visualizers is 87.11. By the independent sample T-test analysis with the significance of .721 (see Table 7.), there is no significant difference between both groups.

Table 7. The Independent Sample T-test Analysis of Diverse Cognitive Styles

Cognitive Style	Value	Average	Std Dev	Average of Std Dev	T-test	
					t	Significance
Visualizer	27	87.11	15.144	2.914	.359	.721
Verbalizer	20	85.4	17.473	3.907		

5.6. Difference in the Diverse Learning Performance of Touring Types

By the analysis on the diverse learning performance of both touring types, the post-test average of the learning performance of ARTTS participants is 95.69, the average of the learning performance of participants with traditional printed brochure is 74.86. By the independent sample T-test analysis with the significance of .000 (see Table 8.), there is extremely significant difference between both groups.

Table 8. the Independent Sample T-test Analysis on the Diverse Learning Performance of Both Touring Types

Touring Type	N	Average	Std Dev	Average of Std Dev	T-test	
					t	Significance
ARTTS	26	95.69	11.422	2.27	5.797	.000***
Printed Brochore	21	74.86	13.215	2.884		

5.7. Difference in the Diverse Cognitive Styles and Learning Performance of Touring Types

Table 9. (see below) shows that there is significant difference on learning performance by diverse touring types, whereas there is no significant difference on learning performance by diverse cognitive styles. Meanwhile, there is no interactive effect between learners' cognitive styles and touring types.

Table 9. The two-way ANOVA analysis on the Learning Performance of the Diverse Cognitive Styles and Touring Types

Resourse	Type 3 Sum of Squares	df	Mean Square	F	Significance
Adjusted Model	5294.703	3	1764.901	11.671	.000

Intercept	325381.710	1	325381.710	2151.730	.000
Cognitive Style	101.176	1	101.176	.669	.418
Touring Type	4744.051	1	4744.051	31.372	.000
Cognitive Style * Touring Type	117.320	1	117.320	.776	.383
Error	6502.403	43	151.219		
SUM	362512.000	47			
Adjusted SUM	11797.106	46			

a. R Square = .482 (Adjusted R Square = .446)

5.8. Focus Group Results

The Focus Group Interviews after the experiment had been recorded in all time and turned into the transcript with highlighted key points to login open coding by Grounded Theory (C. Wu & M. Liao, 1998; Strauss.A, & Corbin.J, 1990). In the the axial coding process, most respondents in the interviews are concerned with System Usability, Expected Benefits, Operative Motive.
The analysis on the Grounded Theory of SUS, observation participating and focus group interviews indicates,

SUS: Pervasive Gaming in ARTTS is interesting, attractive, understandable and satisfying the usability of participants

Self Assessment: All participants said that it was easy to operate the system and to introduce the information about the temple to other people, and they felt satisfied about their own performance with the positive attitude.

Operative Motive: Most participants said that they would like to promote ARTTS with Pervasive Gaming to their friends, indicating ARTTS is highly recommended.

Expected Benefits: Most participants said that they were curious, excited and interested before the gaming started. Whereas, they would like to see the modified version for children with interactive games for the better usability in the future.

6. Conclusion

1. the System Usability of ARTTS was Evaluated to be Excellent

After calculation, the average score of System Usability (SU) is 85.19. The SUS score placement (see Figure 10.) indicates the excellent SU evaluation of ARTTS.

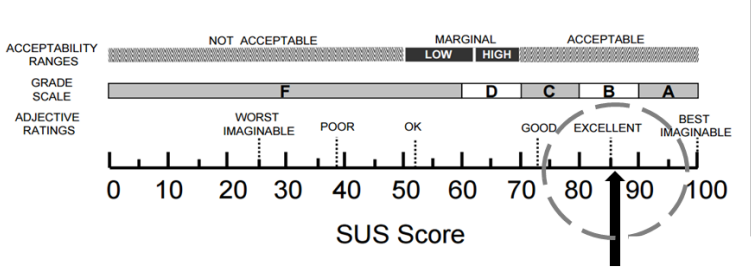

Figure 10. The SUS Score Placement.

2. Lack of Significant Difference in SUS of Diverse Cognitive Styles

There is no significant difference of System Usability (SU) between Visualizers and Vervalizers. The participants described the SU of ARTTS as satisfying. The analysis based on the average indicates that the SU of ARTTS by Visualizers is slightly higher than that by Verbalizers.

3. Lack of Significant Difference in Learning Performance of Diverse Cognitive Styles

By the analysis of both cognitive styles of Verbalizers and Visualizers, there is no significant difference on learning performance between those cognitive styles.

4. Learning Performance of ARTTS is Higher than Printed-Brochure Touring

The average of the learning performance of ARTTS participants is 95.69, the average of the learning performance of participants with traditional printed brochure is 74.86. The analysis with the significance of .000 (see Table 8.) shows that there is extremely significant difference between both groups.

5. Learning Performance of ARTTS is Higher in Both Cognitive Styles

There are no significant differences of both Verbalizers and Visualizers. The learning performance of Visualizers is better than that of Verbalizers. There is extremely significant difference of learning performance between ARTTS and traditional touring type, indicating the learning performance of ARTTS is obviously effective than that of the tradition type. However, there is no significant difference of learning performance between diverse cognitive styles. Meanwhile, there is no interactive effect between participants' cognitive styles and touring types.

The findings of this study suggests that future research on ARTTS will be more functionally proficient by adding the introduction of the temple architecture, three dimensional user interface (3D UI) for innovative experience, and the multiple versions for better touring & learning experience for all ages of family members.

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