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Interactive Visual Representation of Intangible Cultural Heritage using Human-Artificial Intelligence

Jiahui Li[1], *Shuo Wang*[2], *Biljana Jović*[2] *and Minfeng Shi*[1,*]

[1] School of Design and Art, Beijing Institute of Graphic Communication, 102600, Beijing, China

[2] Department of Landscape Architecture and Horticulture, University of Belgrade, 11000, Belgrade, Serbia

SUMMARY: *This study aims to critically examine the design and evaluation of human–AI interactive visualisation systems in authentically representing, communicating, and revitalising Chinese intangible cultural heritage. Employing a quasi-experimental research design with survey-based data collection, the study engaged 300 university students selected through stratified sampling. The findings reveal that human–AI collaboration offers significant opportunities for enhancing the preservation, transmission, and reinterpretation of China's intangible cultural heritage through interactive visual representations. Aesthetic appreciation emerged as a key determinant of user engagement, which, in turn, positively influenced cultural learning outcomes. Additionally, system usability was identified as the second most influential factor contributing to user engagement and satisfaction. The results further indicate that user-friendly AI-based interactive navigation systems foster deeper engagement, leading to enhanced user satisfaction and more effective cultural learning experiences. Overall, the study underscores user engagement as a critical predictor of cultural learning, suggesting that active user participation in AI-driven visualisation processes facilitates greater retention and understanding of intangible cultural heritage.*

KEYWORDS: *Human–AI interaction; interactive visualisation systems; intangible cultural heritage; digital heritage preservation; cultural learning*

1 Introduction

China has been striving hard to establish its soft power in the globalised world [1]. The intangible cultural heritage of the country has been the most important aspect for accessing and sustaining the soft power status, as it provides the country with the desired identity in a globalised world [2, 3]. The term 'intangible cultural heritage' not only includes the living tradition of a society, but also refers to the unique knowledge and practices that formed its cultural identity and heritage and that are passed on from generation to generation [4]. However, [5] has distinguished the intangible culture from the tangible culture and cited that such heritage is comprised of non-material nature and comprises expressions, skills and social practices that are preserved within a society. According to [6], the most effective categorisation of the intangible cultural heritage has been offered by UNESCO, which has grouped five different categories as part of the intangible cultural heritage. This includes oral traditions, performing

*shiminfeng123@163.com
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arts, social practices and rituals, knowledge and practices regarding nature and traditional craftsmanship. Increasingly, policymakers in China are placing greater significance on the preservation of the unique intangible cultural heritage of the country, as the core belief exists in the country that such preservation is not only essential for sustainable development but also constitutes richness and diversity and a means through which significant social, economic and environmental value could be accessed [7].

As the significance of preserving the intangible cultural heritage of the country has been increasing with the passage of time, Chinese policymakers are confronting a range of different challenges in the process [8]. In particular, [9] have found that the increased urbanisation coupled with modernisation, globalisation trends, and the increased Westernisation are posing greater challenges, as such trends are resulting in diminishing public interests. As a result of such changing dynamics, the Chinese government and policymakers are showing greater concerns for the continuation and sustainability of the intangible cultural heritage [10]. Furthermore, [11] are of the view that unlike other industrialised countries, China has been lacking the desired documentation and the transmission channels that are essential for the preservation and continuation of the intangible cultural heritage of the country.

However, the emergence of artificial intelligence (AI) technology and the increased fusion of human creativity and AI technology have been offering a range of opportunities in different walks of life. The technology has also been introduced in the field of intangible cultural heritage, as the technology has been adopted to preserve, represent and reimagine such artefacts [12]. The technology has been changing the existing landscape of Chinese intangible cultural heritage as it offers opportunities for interactive visual representation. The AI technology features, including generative modelling, image recognition and algorithms concerning adaptive visualisation, could significantly transform the existing landscape and could help the Chinese government and policymakers in the better preservation and continuation of the intangible cultural heritage of the country [13]. Increasingly, interactive digital experiences concerning Chinese intangible cultural heritage have been made possible through AI features like multimedia AI tools, neural networks, and computer vision. Although opportunities are emerging in the field as better preservation has been made possible, [14] and [15] have expressed greater concerns and challenges due to the application of the AI technology, as the transformation process thus taking place has been posing challenges in terms of authenticity and ethical representation. Existing research in the field has not yet effectively addressed how authenticity and ethical representation should be balanced with technological innovation while adopting AI technology. This research has been organised with the aim to critically analyse how human–AI interactive visualisation systems can be designed and evaluated to authentically represent, communicate, and revitalise Chinese intangible cultural heritage.

2 Material and Methods

2.1 Research Design

The findings regarding how human–AI interactive visualisation systems can be designed and evaluated to authentically represent, communicate, and revitalise Chinese intangible cultural heritage are based on quasi-experimental design, as a survey-based experimental process has been adopted in the current study. Empirical evidence regarding user interaction, perception and satisfaction with the AI-based visual representation in the area of intangible cultural heritage has been analysed. For the sake of this experimental research, first an AI-based interactive visualisation process has been analysed concerning traditional craft. The visualisation has been conducted through a human-AI co-creative interface, which has been

adopted in the study. The participants of the study have been then asked to interact with the system, and once the interaction has been completed, such participants have been asked to complete a survey. The survey has multiple questions regarding the perceived authenticity, user engagement, usability, and cultural understanding.

2.2 Research Framework

The research framework that has been adopted in this study could be graphically exhibited as in Figure 1:

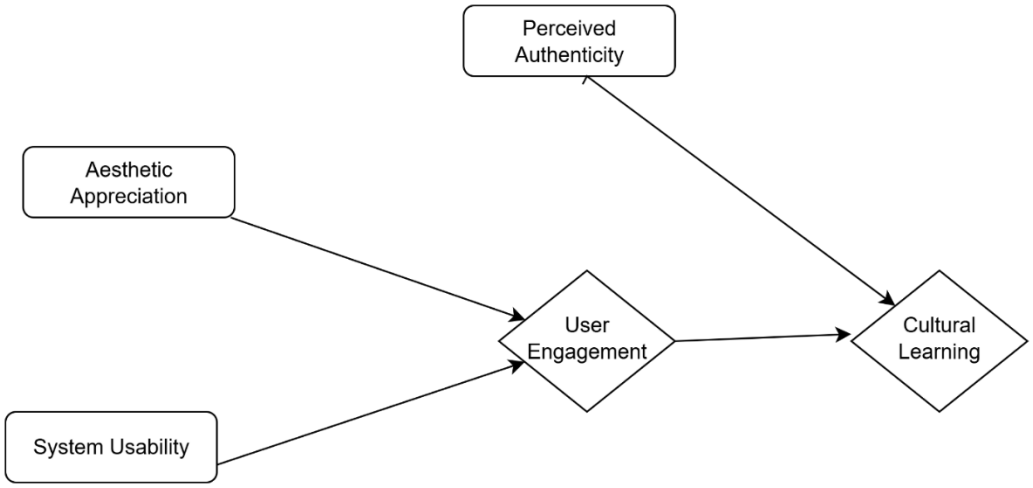

Figure 1: Research Framework

2.3 Sample and Population

The findings regarding how human–AI interactive visualisation systems can be designed and evaluated to authentically represent, communicate, and revitalise Chinese intangible cultural heritage are based on the stratified sampling method. For the sake of this study, students from two core universities, including Tsinghua University and Zhejiang University, have been selected. A total of 300 participants have been selected in this study. The stratified sampling method adopted in this study helped in accessing a large and diverse sample that could certainly contribute to the findings of the study.

2.4 Research Process

The findings within the study are based on the survey research. A questionnaire has been designed for the study, which includes some basic demographic information and five-point Likert-scale questions. The Likert-scale questions were regarding perceived authenticity, user engagement, cultural learning, aesthetic appreciation and system usability. However, before filling the questionnaire, an orientation session has been organised for the participants of the study that elaborated the research process and the core objectives of the research. An interactive phase then took place, where all the participants of the study witnessed AI visualisation for 15 minutes. The participants of the study witnessed Su Embroidery and a dragon dance performance, which have been selected as representatives of the Chinese intangible cultural heritage for this study. The user was given the opportunity to modify a range of different parameters, including colour, texture and composition of AI-assisted tools. For the sake of this study, the system has been programmed to store user logs and responses that have been analysed to assess participants' engagement patterns in the study. Once the interaction has been

completed, all the participants of the study have been asked to complete an online survey.

2.5 Data Analysis Process

For the sake of analysing data, SPSS 27.0 software has been utilised in the study. The analysis comprised descriptive statistics and inferential statistics. Descriptive statistical tools, including mean and standard deviations, have been utilised for the analysis of demographic data. On the other hand, inferential statistical processes, including Cronbach's alpha, Pearson correlation analysis, multiple regression analysis, and ANOVA tests, have been utilised in the study. Cronbach's alpha helped in the assessment of reliability, while the Pearson correlation analysis helped in exploring the relations between different variables, including perceived authenticity, user engagement, aesthetic appreciation, and cultural learning. The Cronbach's alpha has been calculated through the following formula:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} S_i^2}{S_T^2}\right)$$

In the above formula
K = number of items in the scale
Si2= variance of individual item
S^2T= variance of the total test score
On the other hand, Pearson correlation has been calculated through the following formula:

$$r_{xy} = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}}$$

In the above formula rxy = correlation between variable X and Y
X, Y = Mean Values of X and Y respectively
Multiple regression analysis has been conducted in the study with the aim to analyse and predict the power of interactivity on cultural understanding, while the ANOVA tests have been conducted with the aim to analyse differences amongst participants of subgroups who participated in the study. The ANOVA for group comparison has been calculated through the following formula:

$$F = \frac{SS_{between}/df_{between}}{SS_{within}/df_{within}}$$

In the above formula:
SS between = sum of the squares between groups
SS within = sum of squares within groups
Df = degree of freedom

3 Results

3.1 Descriptive Characteristics of the Participants of Study

The descriptive characteristics of the participants who participated in the study has been summarised in the following Table 1:

Table 1: Descriptive Characteristics of the Participants

Description	Variable	Number	Percentage
Gender	Male	168	56%
	Female	132	44%
Age	18 to 22	58	19.4%
	23 to 27	124	41.3%
	28 to 35	118	39.3%
Academics	Arts and Design	82	27.3%
	Cultural Studies	146	48.7%
	Other	72	24%
Previous Experience with intangible cultural Heritage	Yes	176	58.7%
	No	124	41.3%

As exhibited in the above Table 1, the stratified sampling strategy adopted in the current study helped in the desired diversity, as the participants of the study shared diverse backgrounds. In terms of gender, 56% of the participants of the study are male, while 4% of the participants of the study are female. In terms of age, 19.4% of the participants are in the age bracket 18 to 22, while 41.3% of the participants of the study are in the age bracket 23 to 27, while 39.3% of the participants of the study are in the age bracket 28 to 35 years. Additionally, in terms of the academic disciplines, the participants of the study have pursued different studies. In this regard, 27.3% of the participants of the study were specialising in the arts and design discipline, while 48.7% of the participants of the study were specialising in cultural studies. On the other hand, about 24% of the participants of the study were studying in diverse disciplines. In addition, the participants of the study have been asked whether they had any previous experience with intangible cultural heritage. In this regard, about 59% of the participants had prior experience; however, about 41% of the participants in the study did not have any previous experience with the intangible cultural heritage of the country. The diverse features of the participants of the study, which are evident from the gender, age, academic discipline, and prior experience with the intangible cultural heritage of the country, could be termed as a big plus for the current study, as such factors shaped the opinion, beliefs, and attitude of the participants of the study.

3.2 Descriptive Results of the Core Constructs

For the sake of evaluating how human–AI interactive visualisation systems can be designed and evaluated to authentically represent, communicate, and revitalise Chinese intangible cultural heritage, they have been based on the evaluation of Likert-scale questions in the five key areas, including perceived authenticity, user engagement, aesthetic appreciation, and system usability. The descriptive statistics of these different factors, along with Cronbach's α, have been exhibited in the following Table 2:

Table 2: Descriptive Results of the Core Constructs

Description	Mean	Standard Deviation	Cronbach's α
Perceived Authenticity	4.33	0.56	0.88
User Engagement	4.31	0.49	0.90
Cultural Learning	4.19	0.52	0.85
Aesthetic Appreciation	4.47	0.49	0.92
System Usability	4.13	0.61	0.84

The analysis of Table 2 could reveal that all five categories analysed in this study have a mean average score above 4.0 (out of 5), which denotes that all the participants of the study

have strong beliefs regarding the AI-based system. Additionally, the reliability coefficient of all the five categories is above 0.80, which in turn stresses a very high degree of internal consistency. Aesthetic appreciation emerged as the best category, as the mean average for this category is 4.47 and the Cronbach's α is 0.92. The mean score of the key construct adopted in the current study has been graphically exhibited in the following Figure 2:

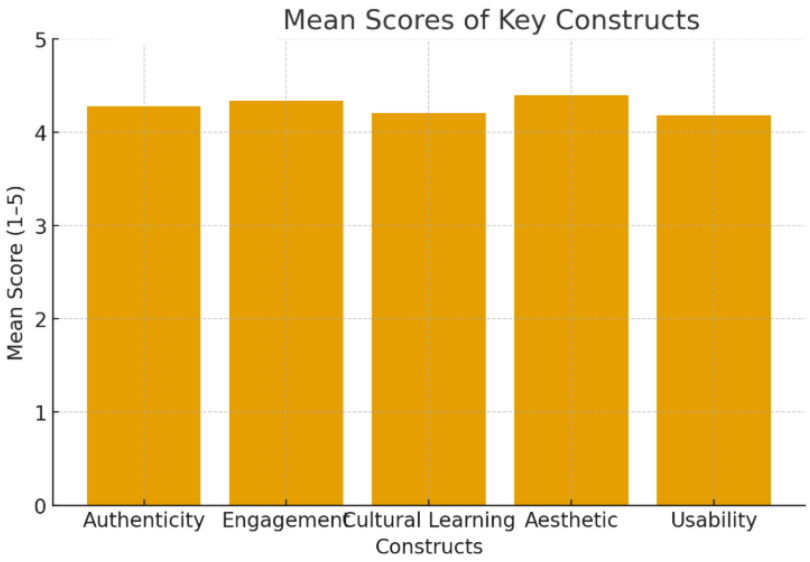

Figure 2: Mean Scores of Key Constructs of Research Model

3.3 Correlation Analysis

In this study Pearson's correlation analysis model has been adopted, which helped in analysing the relationship between the five constructs, graphically exhibited in Figure 1 in the above pages. The results of the Pearson correlation matrix have been summarised and exhibited in the following Table 3:

Table 3: Pearson's Correlations Analysis

Description	1	2	3	4	5
Perceived Authenticity	1	-	-	-	-
User engagement	0.69**	1	-	-	-
Cultural Learning	0.62**	0.77**	1	-	-
Aesthetic Appreciation	0.72**	0.66**	0.61**	1	-
System usability	0.55**	0.57**	0.51**	0.62**	1

From the analysis of the above Table 3, it is very clear that there are significant positive correlations amongst all the key constructs, as the p-value is <0.1 (two-tailed). However, amongst the variables, the user engagement has been showing the strongest correlation with cultural learning. This in turn means that in the situations where the desired interactive visual experience is ensured, this could lead towards significantly better user cultural understanding.

3.4 Multiple Regression Analysis

As there were four different variables that account for the changes in the cultural learning, it is vital to determine the core factor that most significantly predicts the cultural learning outcome. In the following Table 4, multiple regression analysis has been conducted with the aim of

determining which of the five factors most significantly predicts cultural learning outcome.

Table 4: Multiple Regression Analysis

Description of Variable	β	t-value	p-value
Perceived Authenticity	0.26	4.91	0.000
User engagement	0.38	6.86	0.000
Aesthetic appreciation	0.21	3.74	0.000
System usability	0.14	2.44	0.015
$R^2 = 0.68$, Adjusted $R^2 = 0.67$, $F(4, 295) = 135.42$, $p < 0.001$			

From the analysis of multiple regression presented in Table 4, it could be found that about 68% of the cultural learning outcomes result from the four key factors that have been analysed in this study. Of the variables analysed, 'user engagement' is the most vital factor that predicts cultural learning outcome, followed by 'perceived authenticity' and aesthetic appreciation. For the development of a clearer picture, the following Figure 3 highlights the β coefficient.

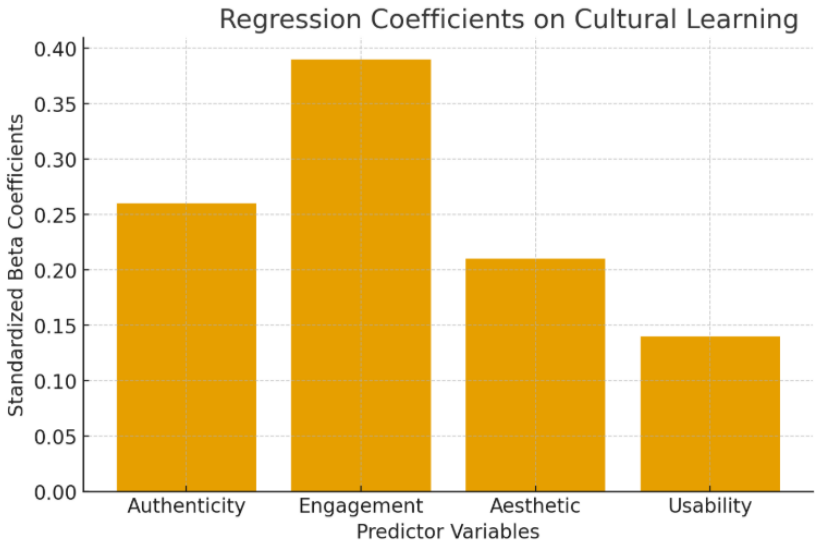

Figure 3: Regression Coefficient on Cultural Learning

From the analysis of Figure 3 above, one could see that the bar corresponding to engagement emerged as the strongest independent variable that accounts for the changes in the cultural learning. The peak value of user engagement is evident from $\beta = 0.39$ in the current study. This in turn means that the user engagement has been contributing to the most substantial impact on learning outcome, which is followed by authenticity and aesthetics.

3.5 ANOVA Analysis

As in this study, students who have been studying different disciplines participated; it is vital to determine whether there is any significant difference in the Likert scale of different participants who shared different academic disciplines. The ANOVA for the perceived authenticity has been computed, which could help in determining whether there is any significant difference in terms of perceived authenticity among different disciplines. Table 5 summarised the key statistics of one-way ANOVA regarding perceived authenticity.

Table 5: ANOVA Analysis

Description	SS	Df	MS	F	Significance
Between Groups	2.74	2	1.37	4.93	0.008
Within Groups	82.31	297	0.27	-	-
Total	85.05	299	-	-	-

From the analysis of Table 5, it is clearer that statistically significant differences exist between perceived authenticity and the different disciplines that the participants of the study have studied. This is evident from the p-value of < 0.001. Furthermore, the post-hoc Tukey tests conducted revealed that the participants of the study who have studied arts and design have been more concerned about the aesthetic authenticity of the AI-created images than the participants who have been enrolled in other programmes. This in turn reflects that the cultural literacy of the participants of the study framed the desired perceptions, as the participants enrolled in the arts and design disciplines rated authenticity as more vital than the participants enrolled in other disciplines.

4 Discussions

This study found strong correlations between the key constructs that were presented in the research model and exhibited in Figure 1. In this regard, the study confirmed that the aesthetic appreciation has positively affected user engagement, which in turn has been affecting the cultural learning of the user. The β coefficient found in this regard is 0.41, and the p-value is <0.01, reflecting that the aesthetic quality of the AI-generated images regarding Chinese intangible cultural heritage plays the most vital role in attracting and sustaining user attention. The findings of the current study thus correspond with the findings of [16], who also pointed out in their conclusion that there are strong interrelations between visually attractive images.

Furthermore, the system usability has been found to be the second most vital factor that contributes to the user engagement and, in turn, cultural learning. As per the findings of the current study, the system usability β coefficient has been found to be 0.28, with a p-value of <0.01. These values stressed that in situations where the AI-based interactive navigation is user-friendly, this could lead to more effective engagement of the user and could contribute to better satisfaction. The findings of the current study are thus in line with the findings of [17], who also found that in situations where effective human-computer interactions are witnessed, this could lead to cognitive ease and ultimately account for better user engagement.

The study also contributes that user engagement has been the key predictor of the cultural learning. The user engagement β coefficient of the current study is 0.39, and the p-value is < 0.01, which in turn demonstrates a situation where a user actively participates in the AI visualisation process; this could help him/her in retaining better knowledge regarding the intangible cultural heritage. This study particularly stressed the emotional element as the most vital factor that fosters cultural learning. The findings of the current study thus correspond with the findings of [18], who have demonstrated constructivist learning theory, stressing that the most effective learning took place in situations that involved learning by interaction.

5 Conclusion

This research has been organised with the aim to critically analyse how human–AI interactive visualisation systems can be designed and evaluated to authentically represent, communicate,

and revitalise Chinese intangible cultural heritage. The findings regarding how human–AI interactive visualisation systems have been designed and evaluated using quasi-experimental design, as a survey-based experimental process has been adopted in the current study. 300 students have participated in the study who were selected on the basis of the stratified sampling method. The core findings of the study stressed that human-AI collaborations are significantly opportunistic for the intangible cultural heritage, as interactive visual representations could significantly enhance the process of preservation, transmission, and reinterpretation of the intangible cultural heritage of China. In this regard, the study confirmed that the aesthetic appreciation has positively affected user engagement, which in turn has been affecting the cultural learning of the user. Furthermore, this study stressed that system usability has been found to be the second most vital factor that contributes to the user engagement and, in turn, cultural learning. As per the findings of the current study, in situations where the AI-based interactive navigation is user-friendly, this could lead to more effective engagement of the user and could contribute to better satisfaction. The study also contributes that user engagement has been the key predictor of the cultural learning. In a situation where a user actively participates in the AI visualisation process, this could help him/her in retaining better knowledge regarding the intangible cultural heritage.

Author's Profile

Jiahui Li, M.A., is a member of the Holographic Arts Center at Beijing Institute of Graphic Communication. He has collaborated with several museums and art galleries, focusing on research and practice in cultural heritage digitization and immersive exhibition design.

Dr. Shuo Wang, associate professor and master's supervisor at the Beijing Institute of Graphic Communication, where he serves as director of the Holographic Arts Center. He is also a research fellow in holography at Center for Ultra-Realistic Imaging, U.K.

Dr. Biljana Jović, associate professor at the University of Belgrade, specializes in descriptive geometry and the geometry of architectural forms. In recent years, she has led and participated in several research projects related to digital visualization, experimental design, and artistic expression.

Minfeng Shi, professor and master's supervisor, visual artist, and Director of the Art Museum at the Beijing Institute of Graphic Communication. His work focuses on the theory and practice of design art, and he has led multiple national and provincial research and art projects.

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