

Testing Mixed Reality Experiences and Visitor's Behaviours in a Heritage Museum



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Abstract This paper aims to test the relationships between technological and functional, and experiential elements of the new realities, developing a conceptual framework based on (Trunfio and Campana, *Current Issues in Tourism*. 23(9):1053–1058, 2020) visitors' experience model for mixed reality in the museum to explore how mixed reality functional elements influence visitors' experiences in museum and post-experiences. Findings validate the influence of mixed reality functional elements on visitors' experiences, showing traditional experiences as a key museum experience to drive 4.0 experiences and post-experience behaviours. However, some theoretical questions remain open, considering the influence of usability requirements on interaction and 4.0 experience on museum post-experience.

Keywords Mixed reality · Smart technologies · Heritage museum · Visitors' interaction · Visitors' experience · Visitors' behaviour

1 Introduction

Mixed reality (MR) is a smart technological interface that combines virtual reality (VR) and augmented reality (AR) to integrate the processes of smart visualisation and immersion with advanced forms of the digital storytelling (Flavián, Ibáñez-sánchez, & Orús, 2019; Kang, Shin, & Ponto, 2020; Rahaman, Champion, & Bekele, 2019; Rokhsaritalemi, Sadeghi-Niaraki, & Choi, 2020; Trunfio, Campana, & Magnelli, 2020; Wang & Xia, 2019). It transforms the museum in a new multisensory and

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experiential space where the interaction between visitors and heritage exhibitions creates innovative forms of experiential value (Bekele, 2019; Fenu & Pittarello, 2018; Little, Bec, Moyle, & Patterson, 2020; Schaper, Santos, Malinverni, Zerbini Berro, & Pares, 2018).

Researchers focused attention on AR and VR covering diverse topics but in a fragmented way (Loureiro, Guerreiro, & Ali, 2020). Some studies analysed AR and VR functional elements and other readapted Pine and Gilmore’s (1999) theoretical framework of experience economy to explore AR and VR effects (Kim, Lee, & Jung, 2020; Lee, Dieck, & Chung, 2020; Dieck, Jung, & Rauschnabel, 2018; Trunfio et al., 2020). The visitors’ experience model for mixed reality in the museum (Trunfio & Campana, 2020) was proposed to measure how MR technological and functional elements impact on visitors’ experience during heritage visits (seven dimensions, twenty-three items).

Although researches on MR explore both technological elements and visitors’ experiences, how the MR technological and functional elements influence both visitors’ experiences in museum and post-experience behaviours represent grey areas and spaces for future investigation.

2 Conceptual Framework

The paper aims to test the relationships between functional and experiential elements of the Trunfio and Campana’s (2020) model (seven dimensions and twenty-three items), integrated with two visitors’ experiential forms, traditional experience (heritage valorisation, and education) and 4.0 experience (entertainment, socialisation, and escape) (Trunfio et al., 2020) and visitors’ behaviour effects (interest towards the new digital technologies, perceive the museum as unique, and promote a new visit to the museum). The conceptual framework is summarised in Fig. 1.

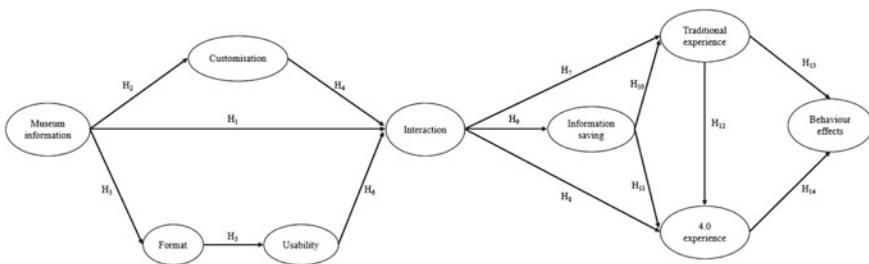


Fig. 1 Conceptual framework

2.1 The Relationship Between Museum Information, Interaction, Customisation, and Format

Traditionally museum visit identifies a direct visitors' interaction with the heritage exhibition, living a self-access to various museum information (Forrest, 2013; Poria, Biran, & Reichel, 2009). The new technologies have reinvented the interaction forms between visitors and heritage (Wang & Xia, 2019), improving the visualisation processes with customisation-information or immersion-information based on MR (Ardito, Buono, Desolda, & Matera, 2018; Fenu & Pittarello, 2018; Not & Petrelli, 2018; Trunfio et al., 2020).

H1: *Museum information has a positive effect on interaction.*

H2: *Museum information has a positive effect on customisation.*

H3: *Museum information has a positive effect on the format.*

2.2 The Relationship Between Customisation and Interaction

Visitors use customisation filters to visualise museum information in own language preferred, defining the access to specific museum information (Poria et al., 2009) that regard to the museum exhibition, services, historical period and city attraction (Trunfio & Campana, 2020; Trunfio et al., 2020).

H4: *Customisation has a positive effect on interaction.*

2.3 The Relationship Between Format and Usability

In contrast, MR integrates visualisation and immersion with interaction, combining audio, touch, video and image elements to promote correct museum information access (Bekele, Town, Pierdicca, Frontoni, & Malinverni, 2018; Flavián et al., 2019; Hudson, Matson-Barkat, Pallamin, & Jegou, 2019; Dieck, Jung, & Han, 2016; Trunfio et al., 2020). However, MR technical characteristics require a specific design in terms of complex hardware, software, and mobile computing (Bekele et al., 2018; Javornik, 2016).

H5: *Format has a positive effect on usability.*

2.4 The Relationship Between Usability and Interaction

MR stimulates visitors' interaction with the museum information (Trunfio et al., 2020). This circumstance occurs when MR respects the visitors' requirements of wearability or usability (Errichiello, Micera, Atzeni, & Del Chiappa, 2019; Dieck, Jung, & Dieck, 2018; Dieck et al., 2016), ensuring a comfortable design, easy-to-use and a clear identification about the access to museum information contents (Trunfio et al., 2020).

H6: *Usability has a positive effect on visitors' interaction.*

2.5 The Relationships Between Interaction, Traditional Experience, 4.0 Experience, and Information Saving

Interaction is a museum service critical aspect, allowing visitors to control their experience with the exhibition (Ardito et al., 2018; Antón, Camarero, & Garrido, 2018; Trunfio & Campana, 2020). Directly, visitors interact with the heritage exhibitions, deepening its contents with forms of traditional experience (heritage valorisation and education), or decide to use other immersive technologies to access at 4.0 experiences (entertainment, socialisation, and escape) (Ardito et al., 2018; Lee et al., 2020; tom Dieck et al., 2018; Trunfio et al., 2020). Indirectly, visitors save their interaction—on museum platforms or personal devices (Trunfio & Campana, 2020)—becoming an integrated part of digital storytelling (Hudson et al., 2019).

H7: *Interaction has a positive effect on the traditional experience.*

H8: *Interaction has a positive effect on experience 4.0.*

H9: *Interaction has a positive effect on information saving.*

2.6 The Relationships Between Information Saving, Traditional Experience, and 4.0 Experience

Information saving adds more value to visitors' experiences, creating digital souvenirs in terms of heritage homage (Bec, Moyle, Timms, Schaffer, Skavronskaya, & Little, 2019; Lee et al., 2020). It reinforces the visitors' social awareness about the heritage valorisation and preservation processes activated by the museum, becoming an attraction point for new and non-expert visitors (Bec et al., 2019; Little et al., 2020; Dieck & Jung, 2017; Trunfio et al., 2020).

H10: *Information saving has a positive effect on the traditional experience.*

H11: *Information saving has a positive effect on experience 4.0.*

2.7 The Relationship Between Traditional Experience and 4.0 Experience

Nowadays, museums use multiple technological interfaces to combine traditional experiences of heritage education and learning with advanced forms e.g. edutainment in which are presented characters of entertainment, socialisation, and escape (Addis, 2005; Antón et al., 2018; Trunfio et al., 2020).

H12: *Traditional experience has a positive effect on experience 4.0.*

2.8 The Relationships Between Traditional Experience, 4.0 Experience, and Visitors' Behaviours

By leveraging visitors' satisfying experiences, the museum becomes a tool to explore the visitors' future behaviours (Kim et al., 2020; Tussyadiah, Jung, & tom Dieck, 2018; Wei, Qi, & Zhang, 2019) in terms of interest towards the new digital technologies; perception of the museum as a place unique, original, and authentic; and how incentive to repeat the visit in the same or similar contexts (Kim et al., 2016; Wei et al., 2019).

H13: *Traditional experience has a positive effect on visitors' behaviours.*

H14: *Experience 4.0 has a positive effect on visitors' behaviours.*

3 Methodology

The empirical analysis interested an Italian heritage museum in which has been realised an important project of MR interface to increase visitors' experiential value. The project integrated AR and VR technologies enhancing visitors in immersive experiences.

A total of 312 data from visitors were collected using a self-administrated questionnaire. The questionnaire analysed two sections: the first section identified visitors' profiles (67% Italian and 37% International); the second section measured the nine constructs with twenty-six reflective multi-item by a seven-point Linkert-type scale (where 1 = strongly disagree, 7 = strongly agree).

A structural equation model (SEM) is used—considering the multivariate normality and linearity assumptions—to analyse the dependence among the observed constructs and their correspondent latent variables (Schreiber, Stage, King, Nora, & Barlow, 2006). Validity tests of the measurement model are conducted through a Confirmatory Factor Analysis and correspondent reliability. The analysis was

performed using the maximum likelihood estimation method provided in LISREL 8 (Jöreskog & Sörbom, 1996).

4 Findings

The evaluation of the psychometric characteristics acquired considering the average variance extracted (AVE), composite reliability (CR), and Cronbach's alpha (α) on twenty-six items of nine constructs, overcome the recommended value of 0.50, 0.70, and 0.70 (MacKenzie, Podsakoff, & Jarvis, 2005) (Table 1). Considering the intra-

Table 1 CFA model

Constructs	Items	AVE	CR	α
Museum information	Exhibition	0.57	0.84	0.83
	Services			
	Historical period			
	City attraction			
Customisation	Personalised information	0.82	0.90	0.96
	Multiple language capability			
Format	Audio	0.66	0.88	0.89
	Images and video			
	Accessible using own mobile device			
	Touch			
Usability	Comfort	0.80	0.92	0.90
	Clever alternative to access information			
	Easy to use			
Interaction	Museum servicescape	0.69	0.87	0.87
	Multimedia elements			
	Other technologies			
Information saving	On museum platforms	0.85	0.92	0.92
	On personal devices			
Traditional experience	Heritage valorisation	0.63	0.77	0.76
	Educational			
4.0 experience	Entertainment	0.68	0.86	0.85
	Socialisation			
	Escape			
Behaviour effects	Increase interest in digital technologies	0.62	0.83	0.81
	Perceive the museum as unique			
	Promote a new visit to the museum			

Table 2 Correlation

		1	2	3	4	5	6	7	8	9
1	Museum information	1								
2	Customisation	0.14	1							
3	Format	0.19	0.03	1						
4	Usability	0.04	0.01	0.19	1					
5	Interaction	0.37	0.18	0.08	0.07	1				
6	Information saving	0.05	0.03	0.01	0.01	0.14	1			
7	Traditional experience	0.13	0.07	0.03	0.03	0.36	0.01	1		
8	4.0 experience	0.11	0.06	0.03	0.02	0.31	0.25	0.51	1	
9	Behaviour effects	0.04	0.02	0.01	0.01	0.12	0.08	0.30	0.21	1

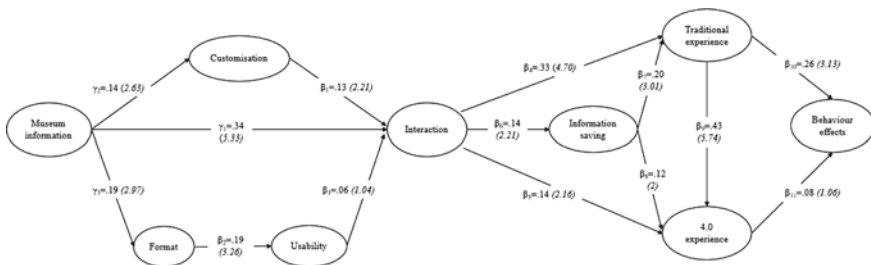


Fig. 2 Estimated results (t-value in parentheses)

correlations among constructs, the discriminant validity of the structure model is verified in all cases (Fornell & Larcker, 1981) (Table 2).

Global fits indicate a model with a good fit ($\chi^2 = 677.24$, d.f. = 285, $\chi^2/d.f. = 2.37$, GFI = 0.90, AGFI = 0.82, NFI = 0.90, NNFI = 0.93, CFI = 0.94, RMSEA = 0.067) (Jöreskog & Sörbom, 1996). Figure 2 shows the support of fourteen hypotheses (H1, H2, H3, H4, H5, H7, H8, H9, H10, H11, H12, and H13) and the rejection of two hypotheses (H6, and H14).

5 Conclusions, Research Implications and Limitations

The research tests the Trunfio and Campana’s (2020) model to analyse the impact of visitors’ behaviour effects under MR condition, identifying some preliminary theoretical and managerial implications that open future scenarios.

Firstly, the positive findings of reliability and global fits allow the theoretical and managerial validation of the Trunfio and Campana’s (2020) model and test the hypotheses conceptualised (Trunfio et al., 2020). Future research should test

the conceptual framework in various museum contexts to improve phenomenon comprehension.

Secondly, the H6 rejection shows how the MR usability requirements are still an important challenge for the museum that should provide interfaces with a more comfortable design and easy to use (Trunfio et al., 2020).

Thirdly, the rejection of H14 indicates how 4.0 experience is not significant in visitors' behaviour effects considering contexts of heritage museums with a high prevalence of heritage valorisation educational contents.

Some questions remain open about: What are the visitors' cultural differences that can influence the visitors' experience and behaviour under MR conditions? What are the other technological interfaces to promote alternative forms of visitors' visualisation and interaction?

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