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Visitor Experience in Digital Museums: Dimensions, Scale Development, and Validation

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Abstract

Purpose – Providing visitors with excellent experience is a key challenge faced by digital museum development. However, the dimensionality of visitor experience in digital museums is under-explored, and there is a scarcity of survey scales for measuring multiple dimensions of visitor experience in digital museums. This study aimed to explore the dimensionality of visitor experience in digital museums and develop a survey scale for measuring multiple dimensions of visitor experience in digital museums.

Design/methodology/approach – This study adopted a mixed method by interviewing 12 digital museum visitors and implemented a questionnaire survey with 982 visitors. The qualitative data was analysed using a thematic analysis technique while the quantitative data was analysed based on exploratory factor (EFA) analysis and confirmatory factor analysis (CFA).

Findings – Based on qualitative results, this study developed a new dimension model for visitor experience in digital museums based on interview research that consists of five experience dimensions: technological, social, emotional, cognitive, and behavioral experience. Accordingly, this study also designed a specialized survey scale to measure these five dimensions. The scale's validity and reliability were verified and purified. This new scale can be used by future survey research on digital museums from a visitor perspective.

Originality/value – This is the first study that empirically explored the dimensionality of visitor experience in digital museums. The study also developed a first survey scale specifically for measuring multiple dimensions of visitor experience in digital museums.

Keywords: visitor experience, digital museum, dimensionality, scale development, scale validation

1. Introduction

Technological development is progressively shaping the patterns and functions of museums, and has given birth to digital museums. Digital museums enable people to visit museum exhibitions without the constraints of space, time, and location (Liao *et al.*, 2020). Meanwhile, many digital technologies, such as dynamic displays, 360° full views, AR, and VR, are widely applied in digital museums, which greatly enrich and improve visitor experiences (Shehade & Stylianou-Lambert, 2020; Trunfio *et al.*, 2018; 2022). Digital museums also improve the inclusion and equality of museum resources, as they can be easily accessed by many people via internet connections (Ahmed *et al.*, 2020; Navarrete & Owen, 2011).

A key challenge faced by digital museums is providing visitors with excellent experience. According to New Museology, museums should be people-centered (Andermann & Arnold-de Simine, 2012), and providing visitors with excellent experience is a precondition for the sustainable development of museums (Recupero *et al.*, 2019). Excellent visitor experience is valuable, which drives visitors to repeatedly visit digital museums (Zollo *et al.*, 2021). Excellent visitor experience also implies that digital museums meet visitors' needs or expectations (MacDonald, 2015; Zhang & Abd Rahman, 2022). However, digital museums have some defects that hinder them from providing excellent visitor experience. The lack of authenticity is a key problem as visitors do not appreciate real exhibits; instead, they browse digital copies of these exhibits (Evrard & Krebs, 2018; Li *et al.*, 2022). Technological and infrastructural defects also undermine visitor experience and hinder visitors from visiting digital museums (Mohd Noor Shah & Ghazali, 2018).

Although past research has extensively investigated visitor experience in digital museums, it was problematic in two aspects. First, some past research viewed visitor experience in digital museums as a unidimensional construct (Ghazali, 2018; Zhang & Abd Rahman, 2022; Zollo *et al.*, 2021) and there is a scarcity of research that probed the dimensionality of such experience. However, visitor experience is multifaceted and has rich connotations (Falk & Dierking, 1992; 2000; Pine & Gilmore, 2011). It also comprehensively reflects visitors' cognitions, emotions, behaviors, and interactions with the museum (Chan& Yeoh, 2010; Roederer & Filser, 2018). Hence, it is inadequate to regard visitor experience as a uni-dimensional construct. Second, the survey scale for visitor experiences specific to digital museums is largely absent in the existing research. Some past research regarding visitor experience in digital museums commonly borrowed scales for measuring visitor experience in physical museums (Guo *et al.*, 2021; Komarac & Ozretić Došen, 2022; Li & Xiao, 2021). However, digital museums differ from physical museums because of digitalization and the differences in exhibition displays, interaction modes, accessibility, inclusion, and resource richness brought about by digitalization (Biedermann, 2017; Evrard & Krebs, 2018; Giannini & Bowen, 2019). It is not appropriate to generalize the survey scales of physical museums to digital museums.

To bridge these two research gaps, this study explored the dimensionality of visitor experience in digital museums and developed a survey scale for measuring multiple dimensions of visitor experience in digital museums. The dimensionality of visitor experience in digital museums was explored via thematic analysis of interview data collected from 12 experienced digital museum visitors from China. The initial scale was developed based on the qualitative results and previous relevant scales. This scale was used to collect quantitative data from 982 digital museum visitors from China. The scale was tested and purified using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). In this way, the study successfully developed and validated the scale of visitor experience in digital museums. The remainder of this paper is organized as follows. The next section reviews related concepts and research, the third section elaborates on the research design, the fourth section reports the empirical results, the fifth section discusses the research results, and the sixth section draws conclusions for the entire research.

2. Literature Review

2.1 Digital Museums

According to the International Council of Museums (2022), a museum is a permanent and not-for-profit institute in the service of society that collects, preserves, researches, interprets, and exhibits intangible and tangible heritage. Open to the public, inclusive, and accessible, a museum fosters sustainability and diversity, and operates and communicates professionally, ethically, and with the engagement of communities, providing diversified experiences for enjoyment, reflection, education, and knowledge learning. Accordingly, a digital museum can be defined as a platform for museum exhibitions that utilize information and computer technology, where historical collections and cultural relics can be displayed and preserved in a digital format (Li & Liew, 2015). Digital museums are derived from traditional physical museums, and their mission is the same as that of physical museums (Srinivasan *et al.*, 2009).

Digitalization greatly enriches the content of museum exhibits, and the forms by which these exhibits are preserved and displayed. The exhibition space in physical museums is limited, and hence many museums prioritize the most representative collections to display. Digitalization removes space constraints; hence, visitors can access a much larger number of collections in digital museums than in physical museums (Biedermann, 2017; Evrard & Krebs, 2018; Giannini & Bowen, 2019). Digital museums are also more accessible than physical museums, as they provide 7-24 services and can be accessed via the Internet without the constraints of geographic location and time (Lo Turco & Calvano, 2019). In addition, digitalization provides unique experiences via advanced digital technologies, such as dynamic displays, 360° full views, VR, and AR, whereas physical museums provide static displays (Mohd Noor Shah & Ghazali, 2018; Shehade & Stylianou-Lambert, 2020; Trunfio *et al.*, 2018; 2022). The above features make digital museums different from physical museums, and it is likely that visitor experience in digital museums varies with physical museums. The next section reviews visitor experience.

2.2 Visitor Experience

Experience, by nature, is neither an objective nor subjective existence. It is constructed, deconstructed, and reconstructed by an individual through their interaction with the external environment. This existence depends on an individual's internal and subjective interpretations of the external world (Dierking & Falk, 1992). Correspondingly, experience can be defined as a stream of perceptions (e.g., emotions and sensations) that occur in a specific context (Gilmore & Pine, 2002). The current business paradigm has shifted from a previous commodity-driven logic to service-driven logic and recent experience-driven logic. What really attracts and retains customers is not goods or services, but rather the experience brought about by these goods or services (Pine & Gilmore, 2013). In the museum world, visitor experience plays a similar role, and is defined as the combination of a visitor's cognitive, emotional, and behavioral responses to the social, individual, and environmental conditions in a museum (Dierking & Falk, 1992).

According to New Museology, novel museums should be people-centered and provide visitors with excellent experiences (Andermann & Arnold-de Simine, 2012). Visitor experience links the subject (i.e., a visitor) and the object (i.e., a museum) and is created by the interaction between the two (Moser, 2010). Without experience, museums are separated from visitors. Goulding (2000) further suggested that the experiential display in a museum, in a modern sense, represents the creation of interactions and scenarios that enable visitors to explore, experience, learn, and appreciate better.

Visitor experience is not a unidimensional construct and comprehensively reflects visitors' perceptions of and interactions with a destination (Falk & Dierking, 1992; 2000; Pine & Gilmore, 2011). In the field of museum research, researchers have failed to achieve a consensus over the dimensionality of visitor experiences. From the perspective of interaction, Falk & Dierking (1992; 2000) developed an Interactive Experience Model for measuring visitor experience in museums, consisting of three dimensions: physical, social, and personal experience. Pine & Gilmore's (2011) four-dimensional model is one of the most frequently used models for measuring visitor experiences in museums. The model comprises four dimensions: escapism, aesthetics, entertainment, and education. Lee & Smith (2015) developed a visitor experience scale for museums based on literature, which consists of five dimensions: escapism, relationship development, education, culture identity-seeking, and entertainment.

Researchers have also developed dimensional models of visitor experience in digital museums. Based on a literature review, MacDonald (2015) developed a three-dimensional model for visitor experience in digital museums, including reflective, behavioral, and visceral experiences. Based on Pine & Gilmore's (2011) four-dimension model, Guo *et al.* (2021) delineated three dimensions of visitor experience in digital museums: joviality, localness, and personal escapism. Likewise, Komarac & Ozretić (2022) classified two dimensions of visitor experience in digital museums: escapism and aesthetics. Based on the Interactive Experience Model (Falk & Dierking, 1992; 2000), Li & Xiao (2021) developed a three-dimension model for visitor experience in digital museums, consisting of physical, social, and personal experiences. Based on Sutcliffe & Gault's (2004) heuristic evaluation scale for VR and Kabassi *et al.*'s (2019) heuristic evaluation scale for virtual tours, Li *et al.* (2022) developed a model for visitor experiences in digital museums, consisting of four dimensions: learning, navigation, interactivity, and authenticity. The above dimensional classifications for visitor experience in digital museums were developed based on previous models rather than empirical evidence regarding visitors' actual experiences in digital museums. It is questionable whether these dimensions authentically reflect current digital museum visitors' experiences. Meanwhile, the above dimension models fail to consider the technological component of visitor experience, whereas digital technologies considerably shape visitor experience (Mohd Noor Shah & Ghazali, 2018). As a result, it is necessary to develop a new model to explain the dimensions of visitor experiences in digital museums.

2.3 Research Related to Visitor Experience in Digital Museums

Many studies have investigated visitors' experiences in digital museums. Mohd Noor Shah & Ghazali's (2018) review research suggested that digital technologies play a crucial role in shaping visitor experience in digital museums. A key challenge for digital museums is the development of new technologies based on the continuously changing visitor needs and expectations. Zollo *et al.*'s (2021) survey research showed that visitors' digital propensity is a positive driver of digital experience, while digital experience is a positive contributor to visitors' identification with and loyalty to the museum. Zhang & Abd Rahman's (2022) survey research revealed the antecedents and outcomes of flow experience in digital museums. Specifically, flow experience is positively affected by information quality, tech-savvy, and system quality. Flow experience is positively associated with visitor satisfaction and loyalty. Elgammal *et al.*'s (2020) survey research evidenced that visitor experience in digital museums positively contributes to visitor satisfaction, memorable experience, and eventually behavioral intentions.

The above research, however, regarded visitor experience as a unidimensional construct and ignored the rich connotation of visitor experience. Some research has also investigated multiple dimensions of visitor experience. Komarac & Ozretić Došen's (2022) survey research examined the role of interactive technology in shaping the two dimensions of visitor experience in digital museums: escapism and aesthetics. Both dimensions are positive contributors to visitor satisfaction. Meanwhile, the two are positively affected by interactivity and negatively affected by skepticism and expectations. Guo *et al.*'s (2021) survey research considered three dimensions of visitor experiences: joviality, personal escapism, and localness. It was found that visitor experience is positively influenced by auditory and visual cues, and the impacts of the two cues on visitor experience are mediated by a sense of presence and emotional state. Li *et al.*'s (2022) survey research considered four dimensions of the visitor experience: learning, navigation, interactivity, and authenticity. It was reported that the digital exhibition of the Forbidden City is interactive, but lacks authenticity and navigation. However, the quality and quantity of information is poor.

Overall, the above research highlights the importance of visitor experience in digital museums and identifies key antecedents and consequences of visitor experience.

2.4 Past Measurement Scales

Past research has primarily used two approaches to measure visitor experiences in digital museums. The first is the unidimensional measurement of visitor experience. For instance, Elgammal *et al.* (2020) used nine items developed by Radder & Han (2015) for measurement. However, Radder & Han's (2015) scale was developed for a traditional physical museum context. Zollo *et al.* (2021) developed a digital experience scale consisting of 12 items, based on Brakus *et al.*'s (2009) brand experience scale. The second is the multidimensional measurement of visitor experience. For instance, Komarac & Ozretić (2022) adapted the tourism experience scales developed by Oh *et al.* (2007) to measure the two dimensions of visitor experience: escapism and aesthetics. Guo *et al.* (2021) adapted the tourism experience escape scale developed by Mody *et al.* (2017) to measure the three dimensions of visitor experience: joviality, personal escapism, and localness. Li *et al.* (2022) adopted Sutcliffe & Gault's (2004) heuristic evaluation scale for VR, and Kabassi *et al.*'s (2019) heuristic evaluation scale for virtual tours to measure four dimensions of visitor experience: learning, navigation, interactivity, and authenticity.

According to the above review, existing survey research has developed measurement scales of visitor experience in digital museums based on experience scales in other contexts, such as physical museums, brand evaluations, tourism, VR, and virtual tours. There is an absence of a survey scale developed specifically in the digital museum context. Hence, it is questionable whether previous scales accurately and comprehensively reflect the rich and complicated connotations of visitor experiences in digital museums. In view of this, the present study was implemented to develop a survey scale for measuring multiple dimensions of visitor experiences in digital museums.

3. Research Method

3.1 Mixed Method

A mixed method was employed to explore the dimensionality of visitor experience in digital museums and to design a survey scale. A mixed method represents an advanced research design, as the advantages of both methods complement each other (Creswell & Creswell, 2005). A qualitative method is suitable for exploring the rich meanings and patterns of social phenomena from the perspective of social actors' observations, perceptions, experiences, and interpretations (Morgan, 2013). This method is also suitable for developing a new theory, as it allows researchers to make free and flexible explorations of complicated social actions and processes and involve themselves in knowledge creation (Kelle, 2006). As a result, this study used a qualitative method to explore and classify various dimensions of visitor experience and to assist in the initial design of survey items. However, the results of qualitative research lack generalizability, objectivity, accuracy, and logical rigor (Morgan, 2013). Consequently, this study employed a quantitative method for testing and correcting the qualitative results. Specifically, a quantitative method investigates social phenomena from a relatively independent and objective perspective, and is suitable for testing existing theories or hypotheses (Kelle, 2006). The results of quantitative research are more generalizable, objective, logically rigorous, accurate, and replicable than those of qualitative research (Morgan, 2013). In this way, a quantitative method fits the present study's needs for testing the dimension model of visitor experiences in digital museums and validating the survey scale.

3.2 Qualitative Method

3.2.1 Semi-structural Interviews

Qualitative data for exploring the dimensionality of visitor experiences were collected via semi-structured interviews in China. An interview offers researchers the opportunity to explore the rich meanings rooted in social lives, as it enables researchers to understand the backgrounds, thoughts, feelings, values, beliefs, experiences, emotions, perceptions, and behavioral patterns of individuals in a real-life scenario (Gillham, 2001). Hence, this study interviewed experienced digital museum visitors from China to explore their actual experience in digital museums. In the interviews, they were asked to discuss their motives for visiting digital museums, evaluate the performance of digital museums, and describe how they experienced digital museums. The exemplary interview questions are provided in Appendix I. The interviews were semi-structured, as this study had a clear direction for exploration, and semi-structured interviews increased the efficiency of data collection.

3.2.2 Sampling and Participants

Suitable interview participants were (1) adults, (2) Chinese residents, (3) frequent visitors to digital museums, and (4) individuals who were willing to share their thoughts and experiences. A purposive sample technique, i.e., deliberately selecting informants who are most capable of answering questions (Beitin, 2012), was adopted to recruit participants. The researchers used their social relations to identify and invite the participants. The sample size was determined by a saturation principle (Francis *et al.*, 2010), that is, the researchers stopped interviewing more participants after they were confident that the existing data were sufficient to identify and classify various dimensions of visitor experience in digital museums. The interviews were conducted via live-streaming videos, and each interview lasted for approximately

one hour. The audio of the interview process was reported using live streaming software. Twelve participants were interviewed, and their profiles are presented in Table 1. The participants were highly diversified in socio-demographic features and motives, and it was expected that they would be able to offer rich and diversified information.

Table 1. The profiles of 12 interview participants

ID	Description
I1	Male, 23 years old. M.Sc. students, majoring in history. Using digital museums as a source for learning and collecting information.
I2	Female, 24 years old. Freelancer. He was interested in writing and visited various types of digital museums for learning and finding inspiration.
I3	Male, 27 years old. An employee working in a high-tech company. He usually visited digital museums related to geography and horticulture.
I4	Female, 31 years old. Government official. Visiting digital museums without a specific purpose. She visited various types of digital museums.
I5	Female, 33 years old. Self-employed. Working in the field of we-media. She visited digital museums to acquire knowledge, search for useful information, and find inspiration.
I6	Male, 36 years. Self-employed. He usually visited digital museums to satisfy his curiosity and kill boring time. He usually visited digital museums related to China's traditional history, especially the military.
I7	Male, 39 years old. An employee in a financial company. He frequently visited digital museums related to military history because of his interest.
I8	Male, 40 years old. An employee in a manufacturing company. He visited digital museums for recreation and entertainment and was interested in a lot of topics.
I9	Female, 41 years old. Housewife. She was interested in arts and traditional culture and frequently visited digital museums for recreation and learning.
I0	Male, 41 years old. A teacher teaching science in a junior middle school. He usually visited digital museums related to science and technology for learning and searching for teaching resources.
I11	Female, 45 years old. Government official. She was interested in Chinese traditional culture and visited digital museums to acquire knowledge and satisfy curiosity.
I12	Female, 51 years old. A senior manager in a large company. She was interested in painting and usually browsed artworks in digital museums.

3.2.3 Data Analysis

The data analysis process was parallel to the data collection process according to the guidelines of Lillis (1999). Paralleling the two processes is also a requirement of the saturation principle, as the researcher has to evaluate the extent to which existing data are sufficient to answer the research question or develop a new theory after the completion of each interview (Francis *et al.*, 2010). In addition, paralleling the two processes also allows researchers to flexibly adjust interview questions to better collect the required data (Lillis, 1999). Therefore, the researchers transcribed and analyzed the interview data immediately after each interview was completed. This study used the thematic analysis technique (Guest *et al.*, 2011) to analyze the data because each dimension of visitor experience in digital museums can be conceptualized into a theme. The data analysis included six steps: (1) familiarizing, (2) coding, (3) theming, (4) reviewing, (5) naming and defining, and (6) reporting.

3.3 Quantitative Method

3.3.1 Questionnaire Survey

An online questionnaire survey strategy was used to collect quantitative data. The questionnaire survey strategy refers to the process of investigating a large number of participants from the target population using the same measurement instrument. This strategy is cost-efficient for understanding the general patterns of a large population (Brace, 2018). As a result, this study was suitable for the present study collecting data on a large number of digital museum visitors' experiences.

3.3.2 Sampling and Participants

Suitable participants were adults who had visited digital museums in China. In this study, a snowball sampling technique was employed to recruit the participants. Specifically, the researchers invited a small number of participants who met the sampling criteria from their social networks. These initial participants were encouraged to suggest other potential participants to their social networks. Thus, the sample size was enlarged via a chain referral process. This survey was conducted online. The researchers uploaded the questionnaire to a survey website, and participants could access the questionnaire by clicking on a URL or screening a QR code via their digital devices. A total of 1022 responses were returned, of which 982 were useable. The basic characteristics of the 982 participants are summarized in

Table 2. The sample was diversified in terms of sex, age, educational level, and monthly income.

Table 2. The basic characteristics of survey participants (N = 982)

		Frequency	Percent
Sex	Male	516	52.5%
	Female	466	47.5%
Age	18 ~ 25 years	206	21.0%
	26 ~ 33 years	218	22.2%
	34 ~ 41 years	223	22.7%
	42 ~ 49 years	158	16.1%
	50 ~ 57 years	90	9.2%
	Above 57 years	87	8.9%
Education	Lower secondary school or below	93	9.5%
	Upper secondary school	232	23.6%
	Associate degree or higher diploma	315	32.1%
	Bachelor's degree	294	29.9%
	Postgraduate degree or higher	48	4.9%
Monthly income (after tax)	Less than 4000 CNY	38	3.9%
	4001 ~ 8000 CNY	313	31.9%
	8001 ~ 12000 CNY	317	32.3%
	12001 ~ 16000 CNY	223	22.7%
	16001 ~ 24000 CNY	60	6.1%
	Above 24000 CNY	31	3.2%

3.3.3 Measurements

This study did not design survey items directly according to the previous scales. Instead, these items were designed after the completion of the qualitative analysis. The survey items were then designed according to the interview results, literature review, and previous survey items. All items were coded on a seven-point Likert scale, and participants were asked to indicate their levels of agreement with a set of statements regarding their experiences in digital museums from 1 (strongly disagree) to 7 (strongly agree). These survey items are reported in Section 4.2, as they are part of the empirical results. The full scale is presented in Appendix II.

3.3.4 Data Analysis

EFA was first performed to explore the construct structure of the survey data. This technique is suitable for testing the construct validity of survey scales as it compresses data into several dimensions according to their internal associations of the data (Fabrigar & Wegener, 2011). This study dropped items with insufficient factor loadings and performed CFA to further test the consistency reliability, construct validity, convergent validity, and discriminatory validity of the modified scale. In addition, descriptive and correlation analyses were performed to evaluate the levels of visitor experience and identify the correlations between the different dimensions of visitor experience.

3.4 Ethical Issues

This study strictly adhered to the ethical principles of anonymity, informed consent, minimized harm, fairness, and confidentiality. The study is part of the first author's Ph.D. research project at the University Putra Malaysia. The ethical issues of the whole research project have been scrutinized and approved by the Research Ethics Committee at the University Putra Malaysia, with reference number: no. 2022204435/research. All the methods included in the study are in accordance with the declaration of Helsinki.

4. Results

4.1 Dimensionality of Visitor Experience in Digital Museums

4.1.1 Thematic Map

Fourteen themes were extracted from 34 codes. These themes were further classified into five categories: technological, social, emotional, cognitive, and behavioral experiences, as shown in Figure 1. Accordingly, the study successfully identified five dimensions of visitor experiences in digital museums. These experience dimensions are intertwined, rather than independent of each other. For instance, technological experience shapes emotional experience, and emotional and cognitive experiences are antecedents of behavioral experience. The following sections elaborate on these five dimensions:

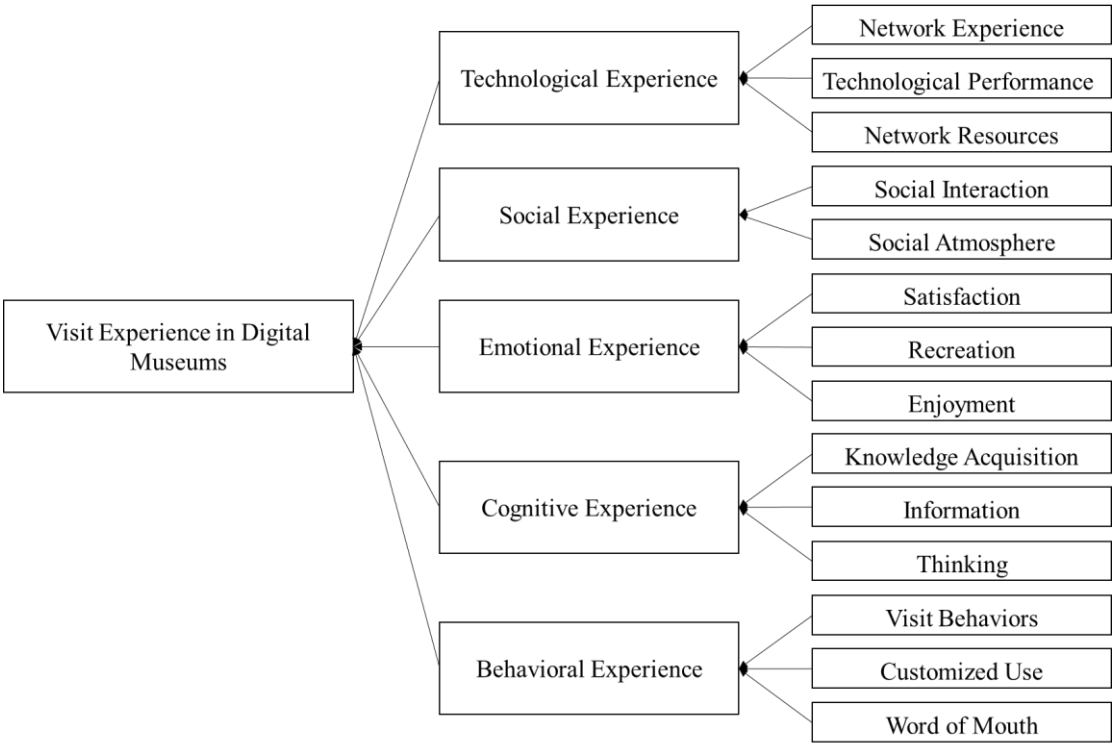

Figure 1. Thematic map (illustrated according to thematic analysis results of interview data)

4.1.2 Technological Experience

Three themes related to technological experience were identified from nine codes. This study defines technological experience as a visitor's evaluation of and response to the technological attributes of a digital museum. This dimension comprises three themes: network resources, technological experience, and network experience. Here, network resources refer to the digital exhibition resources accessed by visitors in a digital museum. The abundance, diversity, and free access to exhibition resources are key advantages of digital museums, and these resources also shape visitor experiences. Technological experience reflects visitors' perceptions and evaluations of digital technologies used in digital museums. Digital technologies offer a platform for exhibition displays and shape visitors' interactions with museums; hence, technological experience is a key component of visitor experience. The network experience captures a visitor's evaluation of the quality and speed of a digital museum's network. A digital museum heavily depends on its network to deliver services; hence, the evaluation of network quality and speed is an important component of the visitor experience. Examples of interview extracts and codes are shown as follows:

> *I am not very sure whether the long loading time is caused by my network problems or museum problems* (An interview extract for the code of loading speed).
>
> *A lot of functions on the museum website are novel to me* (An interview extract for the code of novelty).
>
> *At present, the abundance of exhibits in digital museums is still insufficient* (An interview extract for the code of abundance).

4.1.3 Social Experience

Two themes related to social experience were identified from five codes. Social experience is defined as the social aspects of the digital museum journey, such as interactions with others and the museum's social atmosphere. Although interviewees criticized the lack of interaction and poor social atmosphere in digital museums, this study conceptualized social experience as a dimension of visitor experience. First, museums should satisfy visitors' social needs and provide a platform for visitors to interact with others. Second, the presence of a social atmosphere creates a sense of community, belongingness, and identity, retains visitors, motivates them to enjoy and learn, and provides them with excellent experiences. Third, the lack of social experience is a key disadvantage of digital museums, as digital technologies (e.g., Web 2.0 and Web3.0) have not been fully utilized to promote social interactions. Hence, providing excellent social experiences is a promising development direction for digital museums in the future. Examples of interview extracts and codes are shown as follows:

I believe that the website is lagging behind the social media era and it is difficult for me to interact with other visitors (An interview extract for the code of one-way communication).

I feel as if visiting a website, rather than a museum because of the absence of atmosphere (An interview extract for the code of *atmosphere*).

4.1.4 Emotional Experience

Three themes related to emotional experience were identified from eight codes. Emotional experience refers to a visitor's emotional state at a digital museum. It consists of three themes: enjoyment, recreation, and satisfaction, and the three elements reflect the gratification of a visitor's hedonic or emotional needs. Visiting a digital museum is likely to trigger 'emotional responses as the museum enables visitors' to acquire knowledge, recreate and entertain themselves, escape from daily routines, seek novelty, appreciate artwork, and kill boring time. A digital museum provides excellent emotional experiences if it is able to gratify visitors' hedonic or emotional needs. Emotional experience can also be shaped and enhanced by digital technologies, as these technologies promote the way exhibits are displayed, improve the quality of exhibitions, facilitate visitors to interact with exhibits and others, and provide novel and useful functions. Examples of interview extracts and codes are shown as follows:

I would be happy if the museum meets my expectations (An interview extract for the code of expectation).

When I am alone, I browse various types of digital museums and I can perceive a sense of freedom and peace (An interview extract for the code of escapism).

I like beautiful art works presented in digital museums (An interview extract for the code of aesthetics).

4.1.5 Cognitive Experience

Three themes related to cognitive experience were identified from six codes. Cognitive experience refers to a visitor's cognitive response to museum exhibitions. This dimension of the visitor experience consists of three components: information, knowledge acquisition, and thinking. A digital museum is an information-rich place in which visitors can access many digital resources. They can acquire knowledge, satisfy their curiosity, and find something interesting or useful by browsing these resources. In a digital museum, visitors evaluate the quality, performance, functions, meanings, usages, and origins of exhibits and link them to specific social, cultural, historical, economic, and technological contexts. Thus, digital museums inspire visitors to think. Examples of interview extracts and codes are shown as follows:

I can quickly *learn history by browsing a lot of cultural relics and their introductions* (An interview extract for the code of efficiency).

I feel that *a digital museum is a good place that stores a large volume of cultural and historical information* (An interview extract for the code of storage).

Some exhibits *make me imagine a lot of things* (An interview extract for the code of imagination).

4.1.6 Behavioural Experience

Three themes related to behavioural experience were identified from six codes. Behavioural experience refers to a visitor's behavioural response to environmental stimuli in a digital museum and is the joint outcome of technological, social, emotional, and cognitive experiences. This dimension of visitor experience consists of three components: visit behaviours, customized visits, and word-of-mouth. First, a visitor is motivated to visit a digital museum if he or she believes that the museum will satisfy his or her specific needs or if his or her previous visits provide an excellent experience. Digital museums are always highly flexible and allow visitors to customize their digital tours, for example, what, when, and how to visit. In addition, visitors are likely to recommend digital museums to others if they are satisfied with their tours and/or expect more people to visit them. Examples of interview extracts and codes are shown as follows:

I have bookmarked a lot of digital museums in my browser (An interview extract for the code of bookmark).

It is convenient for me to choose what to visit in digital museums (An interview extract for the code of *customization*).

I have left some comments about digital museums on social media (An interview extract for the code of *propaganda*).

4.2 Questionnaire Design

Based on the above qualitative results, this study designed a scale to measure the five dimensions of visitor experiences in digital museums. The scale was developed based on the qualitative results and previous research. After identifying these five dimensions, the researchers conducted a literature search to find similar constructs and scales in past research.

These scales were subsequently integrated with the qualitative results. Thus, the initial scale was developed, and the survey items are shown in Table 3. The scale consists of 29 items; specifically, TE1–TE7 measure technological experience, SE1–SE5 measure social experience, EE1–EE7 measure emotional experience, CE1–CE5 measure cognitive experience, and BE1–BE5 measure behavioral experience. Based on this, the scale was tested using survey data collected from 982 digital museum visitors in China.

Table 3. A list of survey items

Variables		Survey Items	Sources
Technological experience	TE1.	The websites of digital museums load quickly.	Qualitative analysis of interview results, Chen *et al.* (2021), and Komarac & Ozretić Došen (2022)
	TE2.	The websites of digital museums load fluently.	
	TE3.	A lot of advanced technologies have been integrated into digital museums.	
	TE4.	There are a few technological defects in the websites of digital museums.	
	TE5.	Digital museums provide a large volume of exhibit resources.	
	TE6.	Digital museums provide highly diversified exhibit resources.	
	TE7.	Digital museums provide high-quality exhibit resources.	
Social experience	SE1.	Digital museums allow me to interact with other visitors.	Qualitative analysis of interview results, and Guo *et al.* (2021)
	SE2.	I like the interaction with digital museums.	
	SE3.	I can perceive the atmosphere of visiting a museum.	
	SE4.	I can perceive the existence of other visitors in digital museums.	
	SE5.	I can get in touch with other visitors to digital museums.	
Emotional experience	EE1.	Digital museums enable me to escape from reality.	Qualitative analysis of interview results, Elgammal *et al.* (2020), Guo *et al.* (2021), Komarac & Ozretić Došen (2022), and Wu *et al.* (2021)
	EE2.	Digital museums meet my expectations.	
	EE3.	Digital museums are an ideal place for recreation.	
	EE4.	I am happy to visit digital museums.	
	EE5.	I enjoy my digital museum journeys.	
	EE6.	I am satisfied with digital museums as they gratifies my needs.	
	EE7.	I can kill boring time by visiting digital museums.	
Cognitive experience	CE1.	I have acquired a lot of knowledge by visiting digital museums.	Qualitative analysis of interview results, and Wu *et al.* (2021)
	CE2.	Digital museums have satisfied my curiosity.	
	CE3.	Visiting digital museums stimulates my inspiration.	
	CE4.	Digital museums help me to learn something new.	
	CE5.	My thoughts are active when visiting digital museums.	
Behavioural experience	BE1	I am willing to visit digital museums in the future.	Qualitative analysis of interview results, Meng *et al.* (2022), Marty (2008), and Wu *et al.* (2021)
	BE2	I visit digital museums in a flexible way.	
	BE3	I am willing to recommend others to visit digital museums.	
	BE4	I expect more people to visit digital museums.	
	BE5	I have bookmarked the websites of digital museums in my browser.	

4.3 Exploratory Factor Analysis (EFA)

The major EFA results are presented in Table 4. The KMO value of the full scale is 0.925, suggesting that the sample was adequate for factor analysis. The EFA provides a solution of five factors with eigenvalues larger than 1.0, which is

consistent with the expected construct. These five factors cumulatively explain 66.966% of the variance in the scale; hence, they cover the majority of the information in the scale. As expected, the 29 items loaded on five factors. However, the loadings of EE4 (0.444), EE1 (0.409), and CE4 (0.315) are lower than the threshold of 0.45 (Comrey & Lee, 2013), suggesting that the construct validity of the three was insufficient. Correspondingly, three items were omitted from the scale.

Table 4. Major results of EFA

	1	2	3	4	5
EE6	.925				
EE7	.918				
EE5	.854				
EE3	.842				
EE2	.705				
~~EE4~~	~~.444~~	~~.143~~			
~~EE1~~	~~.409~~	~~.105~~			~~.143~~
CE5		.936			
CE3		.880			
CE2	.110	.609			
CE1		.584			
~~CE4~~		~~.315~~			~~.109~~
SE5			.907		
SE3			.823		
SE4			.698		
SE2			.680		
SE1			.581	.113	
TE2				.915	
TE3				.856	
TE5				.847	
TE6				.720	
TE7				.711	
TE1				.624	
TE4				.608	
BE5					.985
BE2					.806
BE3					.712
BE4					.611
BE1					.594
KMO value			.925		
Eigenvalue	12.661	2.551	1.570	1.457	1.182
% of Variance	43.660	8.797	5.412	5.022	4.075
Cumulative %	43.660	52.456	57.869	62.891	66.966

Notes: Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

4.4 Confirmatory Factor Analysis (CFA)

After excluding three items from the scale, CFA was conducted to verify internal consistency reliability, construct validity, convergent validity, and discriminatory validity. Table 5 presents the major results. All factor loadings are larger than 0.70 and are significant at the 0.001 level, suggesting that the construct validity of all 26 items is qualified.

The Composite Reliability (CR) coefficients of the five subscales are all larger than the threshold of 0.70 (Bacon *et al.*, 1995). Likewise, the Cronbach's alpha coefficients of all five subscales were larger than the threshold of 0.70 (Peterson & Kim, 2013). Hence, the internal consistency reliability of the five subscales were acceptable. Convergent validity was tested based on the Average Variance Extracted (AVE). The AVE coefficients of the five subscales range between 0.661 and 0.802, which are larger than the threshold of 0.50 (Bowen & Guo, 2011). Hence, the convergent validity of the five subscales was also verified.

Table 5. Major results of CFA

	Loading	T statistics	Cronbach's alpha	Composite reliability (CR)	Average variance extracted (AVE)
BE1	0.776	46.031***			
BE2	0.875	81.342***			
BE3	0.854	63.780***	0.900	0.926	0.716
BE4	0.807	52.400***			
BE5	0.915	151.310***			
CE1	0.784	40.800***			
CE2	0.759	31.730***	0.848	0.898	0.689
CE3	0.877	79.146***			
CE5	0.890	85.560***			
EE2	0.834	44.674***			
EE3	0.893	65.627***			
EE5	0.897	70.676***	0.938	0.953	0.802
EE6	0.923	111.040***			
EE7	0.926	97.186***			
SE1	0.751	45.423***			
SE2	0.798	56.198***			
SE3	0.841	78.330***	0.871	0.907	0.661
SE4	0.790	55.788***			
SE5	0.879	130.870***			
TE1	0.714	29.654***			
TE2	0.898	120.084***			
TE3	0.887	98.027***			
TE4	0.737	32.783***	0.913	0.931	0.661
TE5	0.856	62.605***			
TE6	0.789	43.064***			
TE7	0.791	42.854***			

Note: *** $P < 0.001$.

The discriminatory validity of the five subscales was assessed based on the Heterotrait–Monotrait Ratio (HTMT) matrix (Table 6) and the Fornell-Larcker criterion (Table 7). As shown in Table 6, the HTMT ratios of the five range between 0.422 and 0.728, which are all below the threshold of 0.90 (Henseler *et al.*, 2015). As shown in Table 7, the square roots of the AVEs of all constructs are larger than their correlations with the other constructs. Hence, the discriminatory validity of the five subscales was qualified, suggesting that the five dimensions of visitor experience can be clearly distinguished by digital museum visitors.

Overall, after deleting three items, the scale consisted of 26 items that are reliable and valid for measuring the five dimensions of visitor experience in digital museums.

Table 6. The Heterotrait–Monotrait Ratio (HTMT) matrix for the modified model

	BE	CE	EE	SE	TE
BE					
CE	0.530				
EE	0.717	0.620			
SE	0.630	0.422	0.557		
TE	0.728	0.439	0.597	0.685	

Table 7. Fornell-Larcker criterion for the modified model

	BE	CE	EE	SE	TE
BE	*0.846*				
CE	0.464	*0.830*			
EE	0.659	0.553	*0.895*		
SE	0.558	0.363	0.504	*0.813*	
TE	0.663	0.388	0.553	0.612	*0.813*

Notes: The square roots of AVEs are in italics and are presented diagonally.

4.5 Descriptive and Correlation Analysis

Descriptive analysis was performed to evaluate the five dimensions of visitor experience, as shown in Table 8. The results imply that participants' average social experience (mean = 2.979; Std. Dev. = 1.3727) was poor, average cognitive experience (mean = 5.532; Std. Dev. = 1.1898) and emotional experience (mean = 5.522; Std. Dev. = 1.4286) were good, and average technological experience (mean = 4.444; Std. Dev. = 1.3709), and behavioral experience (mean = 4.806; Std. Dev. = 1.5418) were fair. The right panel of Table 8 shows the correlation matrix for the five dimensions of visitor experience. The pairwise correlations among the five range between 0.363 and 0.663 and all these correlations are significant at the 0.001 level. Hence, although the five visitor experience dimensions can be clearly distinguished by visitors, they are closely associated.

Table 8. Descriptive and correlation analysis

	Min	Max	Mean	Std. Dev.	(1)	(2)	(3)	(4)	(5)
Behavioral experience (1)	1.0	7.0	4.806	1.5418	1				
Cognitive experience (2)	1.5	7.0	5.532	1.1898	.464**	1			
Emotional experience (3)	1.0	7.0	5.222	1.4286	.659**	.553**	1		
Social experience (4)	1.0	6.0	2.979	1.3727	.558**	.363**	.504**	1	
Technological experience (5)	1.0	7.0	4.444	1.3709	.663**	.388**	.553**	.612**	1

Note: *** $P < 0.001$.

5. Discussion

A major contribution of this study is the successful construction of a new model that explains visitor experiences in digital museums based on empirical evidence. In contrast to previous dimension models built on literature reviews and/or previous models (e.g., Guo *et al.* (2021), Li *et al.* (2022), Li & Xiao (2021), and MacDonald (2015)), this new model was built according to the thematic analysis of interview data collected from 12 experienced digital museum visitors. The validity of this model was tested and improved by EFA and CFA, and it was found that the five dimensions of visitor experience, including technological, social, cognitive, emotional, and behavioral experience, enjoy good construct, convergent, and discriminatory validity. This study not only confirmed that the five are different constructs and can be clearly distinguished by visitors but also identified positive internal correlations among the five. In this way, this study revealed the rich connotations of visitor experiences in digital museums.

The new dimension model implies that visitor experience in digital museums differs from visitor experience in physical

museums, and it is not feasible to directly generalize dimension models of physical museums to digital museums. The first salient difference is in technological attributes. This study identified a technological dimension of visitor experience that is apparently not included in previous dimension models for physical museums (e.g., Falk & Dierking (1992; 2000), Pine & Gilmore (2011), and Lee & Smith (2015)). The technological dimension implies that technological attributes considerably shape visitor experience in digital museums, which supports the view of Mohd Noor Shah & Ghazali (2018). The second salient difference is that digital museums are more information-rich and accessible than physical museums are. In the interview, participants repeatedly emphasized that they were satisfied with the information provision in digital museums. It is likely that digital museums better satisfy visitors' informational needs because information provision is not limited by space, time, or location. The third salient difference is social experience. Social interaction in physical museums is quite different from that in digital museums. Current digital museums do not apply digital technology to facilitate social interaction. Without social interactions, visitors feel like browsing a website rather than visiting a museum. Hence, current digital museums provide much poorer social experience than physical museums.

Another contribution of this study was the development of a valid and reliable scale for measuring the five dimensions of visitor experience in digital museums. The scale authentically reflects visitors' actual experience in digital museums, as it was designed based on interview data collected from actual digital museum visitors. However, this scale had two limitations. First, it was developed in the Chinese context, and it is questionable whether this scale can be generalized to other contexts because of cultural and language differences. Second, digital museums have evolved rapidly in recent years because of social, economic, and technological changes. It is questionable whether the scale is reliable and valid in the future if digital museums have changed significantly.

6. Conclusion

There is an absence of a dimension model specific to visitor experiences in digital museums. Meanwhile, a specialized survey scale for measuring visitor experience in digital museums is also scarce in the existing literature. With this in mind, the present study explored the dimensionality of visitor experiences in digital museums and developed a scale for measuring multiple experience dimensions. Through qualitative analysis of interview data, a dimension model for visitor experience in digital museums was developed, and the model consists of five closely associated dimensions: technological, social, emotional, cognitive, and behavioral experiences. Hence, visitor experience in digital museums is quite different from visitor experience in physical museums. A scale consisting of 29 items for measuring the five dimensions was designed according to the interview results and the related literature. Through the EFA and CFA, three items were dropped from the scale, and the modified scale is valid and reliable. The new dimension model can be used in future research to explain the rich connotations of visitor experience in digital museums. The scale can be used in future survey research in the field of digital museums.

This study has some limitations. First, this scale was developed in the Chinese context, and it is questionable whether this scale can be generalized to other contexts because of cultural and language differences. Second, digital museums have evolved rapidly in recent years because of social, economic, and technological changes. It is questionable whether the scale is reliable and valid in the future if digital museums have changed significantly. Third, this study failed to distinguish between desktop-based and mobile-based digital museums. According to Pei et al.'s (2023) study, visitor experience varies between the two types of digital museums and previous research results cannot be directly applied to visitor experience in digital museums on mobile. Finally, because a snowball sampling technique was used to collect the quantitative sample, the representativeness of the sample was questionable.

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Authors contributions

Dr. L.Z. carried out the research and wrote and revised the article. Prof. F.D. conceptualised the central research idea and provided the theoretical framework. Prof. M.A.B.Y. designed the research and supervised the research progress; Dr. L.Z., Prof. F.D., and Prof. M.A.B.Y. anchored the review, revisions and approved the article submission. The manuscript has been read and approved by all authors.

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Appendix I: Exemplary Interview Questions

How frequently do you visit digital museums?

For what purposes do you visit digital museums?

What do you commonly do when visiting digital museums?

What resources offered by digital museums are favoured by you?

Which types of digital museums do you visit most frequently?

What are your expectations for digital museums?

Which expectations are met by digital museums?

What characteristics of digital museums are attracting you to visit?

What needs do digital museums meet for you?

What needs do digital museums fail to meet for you?

What are the benefits of digital museums to you?

To what extent you are satisfied with digital museums?

Why you are satisfied (or dissatisfied)?

Could you please offer some recommendations for improving digital museums?

In your opinion, what are the key differences between physical and digital museums?

Which types of museums do you prefer? Why?

Are you willing to recommend others to visit digital museums? Why?

Appendix II: The Full Scale of Visitor Experience in Digital Museum

Regarding your experience of visiting digital museums, please indicate the extent to which the following statements accurately describe your experience from 1 to 7 (1 = strongly disagree; 2 disagree; 3 = somewhat disagree; 4 = neither agree nor disagree; 5 = somewhat agree; 6 = agree; 7 = strongly agree).

NO.		1	2	3	4	5	6	7
TE1.	The websites of digital museums load quickly.	☐	☐	☐	☐	☐	☐	☐
TE2.	The websites of digital museums load fluently.	☐	☐	☐	☐	☐	☐	☐
TE3.	A lot of advanced technologies have been integrated into digital museums.	☐	☐	☐	☐	☐	☐	☐
TE4.	There are few technological defects in the websites of digital museums.	☐	☐	☐	☐	☐	☐	☐
TE5.	Digital museums provide a large volume of exhibit resources.	☐	☐	☐	☐	☐	☐	☐
TE6.	Digital museums provide highly diversified exhibit resources.	☐	☐	☐	☐	☐	☐	☐
TE7.	Digital museums provide high-quality exhibit resources.	☐	☐	☐	☐	☐	☐	☐
SE1.	Digital museums allow me to interact with other visitors.	☐	☐	☐	☐	☐	☐	☐
SE2.	I like the interaction with digital museums.	☐	☐	☐	☐	☐	☐	☐
SE3.	I can perceive the atmosphere of visiting a museum.	☐	☐	☐	☐	☐	☐	☐
SE4.	I can perceive the existence of other visitors in digital museums.	☐	☐	☐	☐	☐	☐	☐
SE5.	I can get in touch with other visitors in digital museums.	☐	☐	☐	☐	☐	☐	☐
~~EE1.~~	~~Digital museums enable me to escape from reality.~~	☐	☐	☐	☐	☐	☐	☐
EE2.	Digital museums meet my expectations.	☐	☐	☐	☐	☐	☐	☐
EE3.	Digital museums are an ideal place for recreation.	☐	☐	☐	☐	☐	☐	☐
~~EE4.~~	~~I am happy to visit digital museums.~~	☐	☐	☐	☐	☐	☐	☐
EE5.	I enjoy my digital museum journeys.	☐	☐	☐	☐	☐	☐	☐
EE6.	I am satisfied with digital museums as they gratifies my needs.	☐	☐	☐	☐	☐	☐	☐
EE7.	I can kill boring time by visiting digital museums.	☐	☐	☐	☐	☐	☐	☐
CE1.	I have acquired a lot of knowledge by visiting digital museums.	☐	☐	☐	☐	☐	☐	☐
CE2.	Digital museums have satisfied my curiosity.	☐	☐	☐	☐	☐	☐	☐
CE3.	Visiting digital museums stimulates my inspiration.	☐	☐	☐	☐	☐	☐	☐
~~CE4.~~	~~Digital museums help me to learn something new.~~	☐	☐	☐	☐	☐	☐	☐
CE5.	My thoughts are active when visiting digital museums.	☐	☐	☐	☐	☐	☐	☐
BE1	I am willing to visit digital museums in the future.	☐	☐	☐	☐	☐	☐	☐
BE2	I visit digital museums in a flexible way.	☐	☐	☐	☐	☐	☐	☐
BE3	I am willing to recommend others to visit digital museums.	☐	☐	☐	☐	☐	☐	☐
BE4	I expect more people to visit digital museums.	☐	☐	☐	☐	☐	☐	☐
BE5	I have bookmarked the websites of digital museums in my browser.	☐	☐	☐	☐	☐	☐	☐

Note: CE4, EE1, and EE4 are excluded because of their lack of validity.