International public cultural digitalisation: Technology, space, and service

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Abstract

Introduction. How to provide intelligent and efficient cultural public services is a global issue. Based on the conceptualisation of '*public cultural digitalisation*', this study aims to conduct a review of international cutting-edge research on public cultural digitalisation and anticipate future research directions.

Method. Under the guidance of experts specialising in public culture, a comprehensive retrieving, retrospecting, screening, data extraction and result analysis of relevant literature regarding the key issues of public cultural digitalisation were conducted, 84 core papers selected for analysis.

Analysis. Three researchers extracted the core information elements of the selected literature based on the coding scheme, and thematic analysis method was used to conduct text coding on Nvivo.

Results. A knowledge framework of the international public cultural digitalisation with themes of '*technology*', '*space*' and '*service*' is conducted, potential systemic risks that public cultural digitalisation may encounter identified.

Conclusion. An integrated knowledge framework for public cultural digitalisation constructed in this study can serve as an interpretive tool in user-oriented, multi-party coordinated, and local-oriented application scenarios.

Introduction

With unprecedented technological progress, cutting-edge technologies like AI, 3D, machine learning, VR, and IoT (Quigley et al., 2024; Shahzad et al., 2024) are rapidly iterating. Digitalisation-driven innovation has become a global strategic priority. Amid this, global digital transformation is reshaping public cultural services: 'digital natives' demand more attractive (Palumbo, 2022), interactive (Fanea-Ivanovici & Pană, 2020), and low-intervention (Malinowski, 2004) services, making 'user-centered' principles redefine the development logic of this field. Since social governance, well-being, and cultural identity are affected by public cultural services, many countries are building digital governance frameworks to maximise the multiplier effect of digitalisation (Humbel et al., 2024) and its positive role.

The global digital wave has not generated universal benefits. Resource imbalances and information asymmetry persist across nations, institutions, and groups (Hegarty & Holcombe-James, 2024; Lamberti et al., 2025). Public cultural institutions responsible for inheritance of civilisation and social equality should adapt to technological changes, explore new approaches, and enable equal access to diverse knowledge (Pesce et al., 2019), helping alleviate issues like the 'digital divide' and 'digital detachment'.

'Public culture' is a concept with distinct Chinese characteristics, and international research in this field lacks systematic reviews and in-depth analysis. However, 'how to provide the public with intelligent, convenient cultural services' is a global issue. To capture international progress in public cultural digitalisation, this study employs thematic analysis method to conduct a literature review systematically in relevant research in the recent 25 years.

Conceptual definition

The understanding of 'public culture' varies across contexts. In this paper, 'public culture' refers to cultural resources and services that are accessible, guaranteed, and easily available to public (Li, G., & Zhang, H, 2021). *Public Cultural Service Guarantee Law of the People's Republic of China* (The National People's Congress of the People's Republic of China, 2016) clearly defines the conceptual connotations of public cultural services and infrastructures: 'Public cultural services' include 'book reading, art popularisation, science popularisation, and Internet access'; public cultural infrastructures are cultural venues represented by libraries, museums, cultural centers, etc. Internationally, there is no theoretical framework yet fully matching its connotation and extension.

Digitisation describes the conversion of an object's physical format into a digital version (Simon, 1995; Lee et al., 2015). Whereas it focuses on the process of such creation, digitalisation emphasises the application of digital artifacts within business process (Gradillas & Thomas, 2025). To define the scope of included literature, this paper, drawing on existing theoretical literature (Pontier, 2013; Holden, 2007; Gradillas & Thomas, 2025; Li et al., 2024) and frameworks for digital cultural governance (European Economic and Social Committee, 2018), defines 'public cultural digitalisation' as the process of adopting, applying and utilising digital artifacts within workflows to better preserve, exhibit and disseminate public cultural resources, thereby providing the public with equal, accessible, efficient cultural services and meeting citizens' basic cultural needs.

Methodology

This study conducted a literature review systematically to synthesise relevant literature: screening and analysing materials by specific criteria to scientifically identify, evaluate, and explain targeted research questions and phenomena (Siddaway et al., 2019). Firstly, the team identified key elements related to public cultural digitalisation (include actors, motivations, and models) from significant literature on the topic and compiled an informal questionnaire. Secondly, consultations with experts in library domain were conducted to identify priority elements, thereby defining the key issues and establishing retrieval strategies. Thirdly, the primary retrieval was conducted on the

WOS, and retrospective retrieval was conducted by reviewing previous literature for supplementation. Subsequently, samples were manually screened to ensure representativeness, scientificity, and quality following specific selection criteria (see Figure 1). Next, with in-depth reading of literature to assess quality based on content, methods, and conclusions, 84 core papers were selected for analysis. Finally, thematic analysis was used to extract, integrate, and analyse data and text coding was conducted.
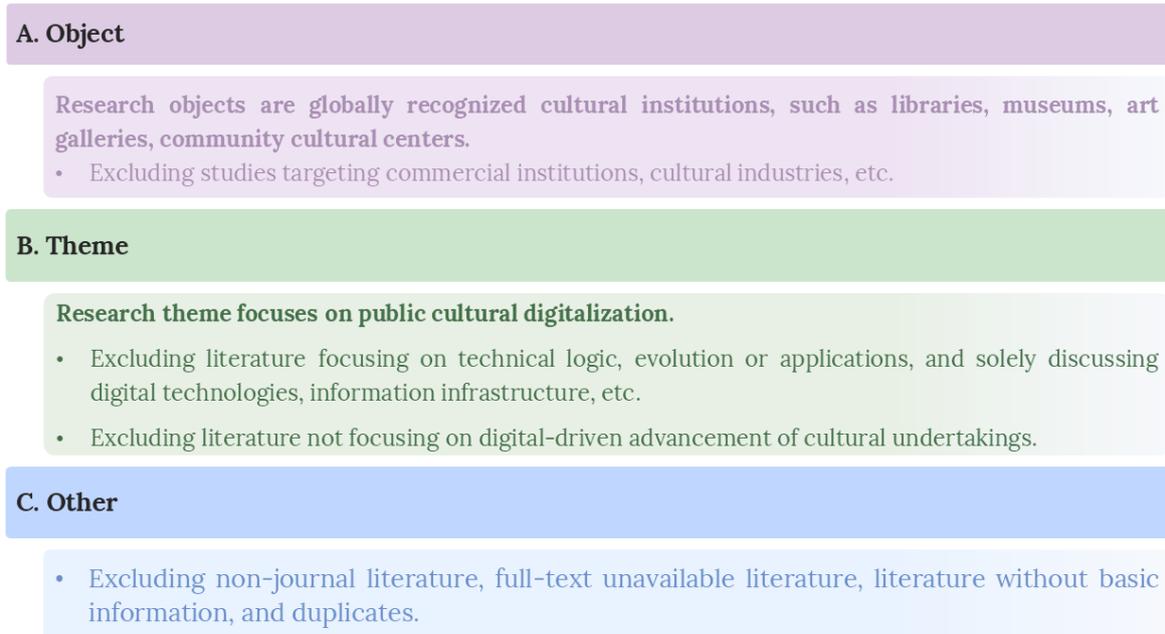
A. Object

Research objects are globally recognized cultural institutions, such as libraries, museums, art galleries, community cultural centers.
- Excluding studies targeting commercial institutions, cultural industries, etc.

B. Theme

Research theme focuses on public cultural digitalization.
- Excluding literature focusing on technical logic, evolution or applications, and solely discussing digital technologies, information infrastructure, etc.
- Excluding literature not focusing on digital-driven advancement of cultural undertakings.

C. Other

- Excluding non-journal literature, full-text unavailable literature, literature without basic information, and duplicates.

Figure 1. Literature selection criteria.

Text data were categorised into three themes to develop the coding scheme and conduct the coding of extracted content (see Table 1). Extraction of information elements was conducted by three researchers specialising in LIS together, with the coding work completed on Nvivo.

Theme	Extracted content
Technology	Type, object, implementation, application scenario, advantage, defect
Space	Type, technology, feature, case, hidden risk
Service	Type, feature, mode, application scenario, purpose, risk

Table 1. Coding scheme.

Results

Based on coding analysis and existing theoretical research (Li et al., 2024), a knowledge framework of the international public cultural digitalisation has been constructed as Figure 2.
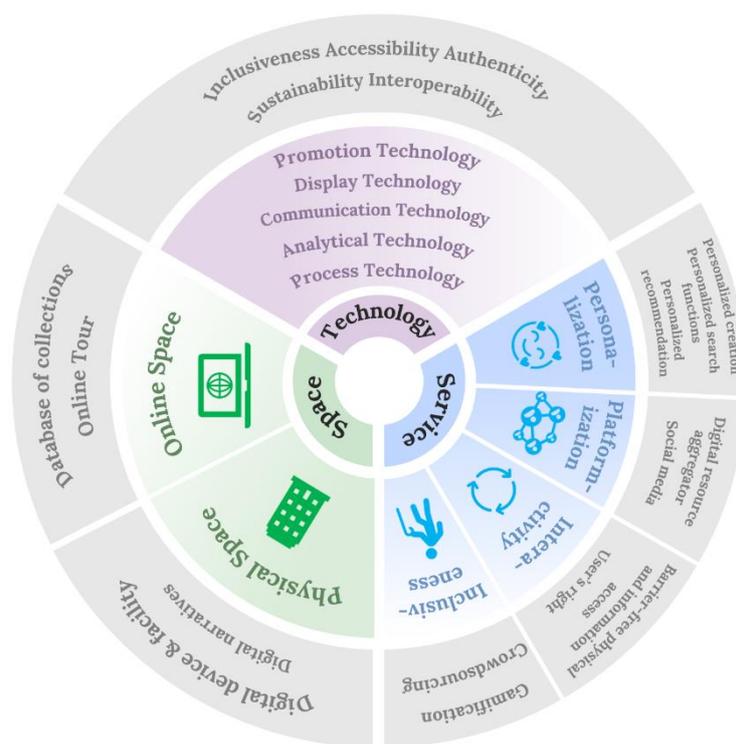
Figure 2. Knowledge framework of the international public cultural digitalisation.

Theme 1: core technologies

Cultural institutions have accelerated data resource integration–including that of digital cultural heritage information and ontology-based domain knowledge. Current technical research mainly focuses on data collection, resource description, knowledge association, and visualisation of multi-source heterogeneous resources, with cultural heritage as a key application field.

Data collection and resource description

Specialised methods for data collection, identification, extraction, and description are developed based on cultural resource characteristics and application scenarios. For example, a metadata extraction method based on automatic semantic annotation is used to standardise the indexing of cultural resources in minority language regions (Tanasijević & Pavlović-Lažetić, 2020); for knowledge organisation needs in historical or artistic archives, handwritten text recognition technology enables the automatic transcription of historical handwritten documents into natural language (AI Kalak & Baraldi, 2023).

Knowledge association

Primarily, it focuses on identifying entity and building links to reveal intrinsic relationships within cultural heritage knowledge, realising a semantic-level integration and discovery (Windhager et al., 2019). Chae et al. (2016) have proposed an automated resource clustering method based on crowd-sourced information, treating diverse public interpretations and comments on artworks across social media platforms as 'folksonomy' tags to construct artwork association networks.

Digital twin

Digital twin technology achieves detailed and accurate documentation of cultural heritage by data collection, modeling and simulation (Siliutina et al., 2024; Yeniasır & Gökbulut, 2022). For instance:

3D modeling and VR are utilised to digitally replicate temples in Bali, Indonesia (Darmawiguna et al., 2020); photogrammetry and 3D modeling are employed to reconstruct Shuri Castle in Japan after its fire damage in 2019 (Elisabeth, 2020).

Long-term preservation technology
This technology aims to address obsolescence caused by technical iterations in file formats, hardware, and other components (Balogun & Adjei, 2019). UNESCO highlights that preservation of digital heritage requires measures throughout the entire life cycle of digital information, from creation to access. Key measures involve using compatible and portable file formats and software (von Schorlemer, 2022), and standardising metadata and storage protocols to ensure long-term data accessibility (Siliutina et al., 2024).

Theme 2: space
Recent digital advancements have provided technological means to overcome the physical constraints of spaces (Song & Evans, 2024), offering more immersive, interactive, and narrative-driven cultural experiences for users (Echavarria et al., 2022; Wagner & de Clippele, 2023). Current research mainly focuses on 'virtual space construction' and 'augmented reality'.

Digital virtual space and online tour
In recent years, immersive and interactive 'virtual exhibition halls' and 'online tours' –integrating tangible contents (e.g., cultural relics, artworks, films) and related information from physical cultural spaces into multimedia databases for digital exhibition (Szabo et al., 2017)–have become research focuses. One common approach is uploading digitised collections and related information to virtual spaces for remote access (Yeniasır & Gökbulut, 2022), such as cultural infrastructures like Europeana, Japan Search, and Cultura Italia (Humbel et al., 2024). Further, GIS (Amato et al., 2017), 360° panoramic imaging, and 3D modeling enable the simulation of historical situations, tour navigation, and exhibit interaction, offering users an in-depth interaction with cultural heritage (Wagner & de Clippele, 2023). For instance, the Statens Museum for Kunst (SMK) uses 360° panoramas to create a fixed-perspective interactive virtual venue, allowing users to freely explore it by manipulating the navigation cursor (Meinecke et al., 2022).

Studies have shown that gamified interaction design enhances user attention and stimulates continuous willingness to learn. For example, users can take a 'virtual roller coaster' in a VR app to tour European countries with cultural heritage descriptions on both sides (Pappa et al., 2018); the simulation of natural and social environment in Iran's Kandaan region is achieved by a VR-based digital framework (Hajirasouli et al., 2021), letting visitors perceive the endangered local heritage.

Digitised physical space and digital narratives
Immersive digital technologies can enrich on-site experiences and activate cultural perception (Yap et al., 2024), thereby strengthening the educational function of public cultural spaces (Zhang et al., 2018). Hence, creating physical-virtual interacted environments has become main direction of current exploration.

General strategies include: (1) Setting up intelligent device experience areas, physical-virtual integrated exhibition areas, and interactive game areas, etc. in cultural venues, thus providing multi-sensory experiences and stimulating users' desire for exploration through physical engagement (Kosmas et al., 2020; Pinto & Huertas, 2025). (2) Using 'digital storytelling' techniques to enable users to interact with exhibits, which in turn allows the exhibits to overcome physical space constraints (Fernandes & Casteleiro-Pitrez, 2023) and vividly convey historical stories and cultural implications (von Schorlemer, 2022). One example is using visual reconstruction to restore the surroundings of buildings and cultural heritage sites. 'My Roman Pantheon' project exemplifies this. Based on a tangible interactive facility, it enables visitors act as Romans and participate in religious ritual to perceive 'cultural presence' (Petrelli & Roberts, 2023).

However, the digitalisation needs to strike a balance between the '*virtual*' and the '*reality*', as an excessive number of technical devices may lead to excessive cognitive load on users, making them feel tired and confused (Fernandes & Casteleiro-Pitrez, 2023). Transplanting large and complex architectural sites into exhibition spaces may also result in the loss of their original cultural background information and undermine the narrativity of resources (Hajirasouli et al., 2021).

Theme 3: intelligent service

Discussion about intelligent services can be summarised as four dimensions: interactivity, inclusiveness, platformisation and personalisation.

Interactivity

International excellent practices note that enhancing the playfulness and sense of participation of the services further drives user interaction. Adding '*gamification*' elements (Kosmas et al., 2020) boosts entertainment, thereby improving users' self-value perception (Wang & Meng, 2024). Meinecke (2022) noticed that virtual museums lack of elements that interact with human sense (architecture, sounds, smells, etc.), often making users feel isolated; gamified modules (e.g., simulated sound effects, multiplayer interaction) strengthen users' emotional bonds. Integrating game elements with intelligent devices better connects millennials with traditional culture, promoting their historical awareness and cultural identity. Many renowned heritage sites also use games to attract visitors to visit obscure cultural heritages (Petrelli & Roberts, 2023).

The widespread application of crowdsourcing has significantly boosted the interactivity of online service platforms by encouraging user participation in digitalisation (Smith & Rowley, 2012). Users are deeply involved in the entire process of digital resources on the platform–from creation to review–fostering a '*user-led*' framework. Terras (2011) notes that digital resources created by amateur enthusiasts often fill gaps left by memories in traditional cultural institutions. For instance, projects like '*Digital Voices*' encourage users to upload oral archives and co-create digital stories (Shiri et al., 2022); '*PALIMPSEST*' project in Greek allows users to add stories and comments via mobile apps, with plugins automatically generating animations for their uploads (Mantzou et al., 2023).

Inclusiveness

To promote equity and ensure digital dividends benefiting all (Fanea-Ivanovici & Pană, 2020), issues about '*inclusiveness*' should be kept exploring. For barrier-free physical and information access (Trivyzadakis, 2023), cultural institutions focus on age-specific and group-specific design in spatial layout, collections presentation, and user services to meet the needs of the visually, hearing, and cognitively impaired, the elderly, etc.–such as touch interaction modules and audio guides (Kosmas et al., 2020). Scholars note that ending '*digital exclusion*' requires not just infrastructure but improvement of overall digital literacy; for tech-challenged groups, institutions should offer training and information platforms to resolve users' confusion (Manžuch & Macevičiūtė, 2020).

Inclusiveness also means respecting users' freedom to choose whether to use digital technologies (Manžuch, 2017). Users of different ages and backgrounds have varying preferences–for example, older adults often prefer print resources, thus public libraries should balance the needs between print and digital resources (Smith & Rowley, 2012). Moreover, digitalisation is a right for users, not an obligation; cultural institutions must cede space for individuals to refuse digitalisation (Giest & Samuels, 2023).

Platformisation

From an omnimedia perspective, online platforms–cultural digital platforms, social media, etc.– deeply empower intelligent services. As digital resource '*aggregators*', official platforms offer free and open access to high-resolution, high-quality resources, ensuring equal public access and boosting diverse cultural transmission (Capurro et al., 2024), like the EU's Europeana (Markellou,

2023). Amateur platforms, by contrast, prefer 'communication' and 'interaction', providing channels for private collection sharing and sparking enthusiasts' passion for cultural heritage (Terras, 2011).

Serves as a public communication channel, social media makes discussions on cultural heritage more inclusive, democratic, and engaging (Manžuch, 2017). On widely used online communities such as Instagram, Facebook, and YouTube (Bramantyo & Ismail, 2021), cultural institutions can develop customised promotion and marketing strategies according to different tones, target audiences, and transmission mechanisms (Brumana et al., 2018). Entertainment, interactivity, trendiness, customisability, and word-of-mouth significantly enhance the user visitation experience (Luo et al., 2022). By offering heritage-themed content such as podcasts, audio guides, articles and threads on these platforms, cultural institutions can enhance topic relevance and marketing effect (Samaroudi et al., 2020), improving the visibility of services.

Personalisation

Driven by technology, 'user-centered' services have become the core direction of transformation in public cultural internationally, aiming to meet the differentiated needs of diverse groups. For instance, general users are interested in gaining basic cultural information, while CH experts are more likely to seek detailed and richer data for studies (Amato et al., 2017). Analysing user behavior becomes crucial for platforms to understand user preference, involving capturing behavioral traces like comments and sharing to predict their cultural interests (Pesce et al., 2019), or extracting implicit user data from questionnaires and system logs (Amato et al., 2017) to enable precise recommendations and resource customisation.

Personalised functions are deeply embedded in various online cultural platforms. (1) Personalised search functions, including allowing users to filter results by their preferred artistic styles (Meinecke et al., 2022), matching users' search intentions with features of cultural heritage (such as figures or architectures) and related digital resources (Zeng et al., 2022), so as to reduce the difficulty of retrieval; (2) Personalised recommendation, such as a 'personalised graph-based recommendation framework' proposed by Minkov et al. (2017) integrating and scoring users' browsed content via their tags, guiding them to select 'high-score' resources which boasts higher accuracy and efficiency with limited data. (3) Personalised creation, including supporting users in creating personalised collection lists similar to those on Spotify and iTunes (Pesce et al., 2019).

Discussion

Features

Public cultural digitalisation, a focus across fields of LIS, social sciences, engineering, etc., reflects the interplay between 'humanity' and 'digitisation'. International research on it is closely tied to frontier practices, which explores the process of integrating digitalisation into resource development, service innovation, and intelligent management around issues such as information literacy and digital inclusion, aiming to enhance user experience and cultural well-being in digital society. Methodologically, it is highly interdisciplinary with the convergence of data-driven and theory-driven methods.

Risks

As the key to breaking new ground, risks in digitalisation are highlighted: technologically, it struggles to fully preserve cultural heritage's original essence, oversimplifying interpretations of cultural connotations or distorting content (Abdoh, 2025; Lu et al., 2025). Moreover, technology divorced from real needs may reduce costly smart devices to mere ornaments (Kim et al., 2019; Fernandes & Casteleiro-Pitrez, 2023). Additionally, cultural institutions have not yet fully established a cooperative mechanism for the collaborative regulation of risks in digital transformation (Warren & Matthews, 2018). Further, public cultural digitalisation is rooted in its 'public' welfare nature. Market entities involved in digitalisation investment may withdraw due to

funding depletion, low returns, or lack of safeguards, leading to project stagnation and adverse impacts on stakeholders (Humbel et al., 2024; Manžuch, 2017). Many institutions lacking supportive standardised systems (Noehrer et al., 2021), a shortage of digital professionals in grass-roots cultural institutions (Preuss, 2016), and insufficient digital competency of institutional staff (Leguina et al., 2021; Rafiq et al., 2018) have become common global issues.

Goals

'Digitalisation' is a bridge to better services, not an end. Public cultural digitalisation research must stay human-centered and practice-oriented. Future research should focus on Human-AI Collaboration to explore optimal designs for digital cultural services, such as prioritising service innovation, smart application development, and new digital risk governance derived from information services, with a focus on enhancing accessibility, usability, and interactivity. Meanwhile, efforts should be made to build a theoretical system, explaining the drivers, management, safeguards, and collaborative mechanisms of public cultural digitalisation.

Conclusion and limitation

This study preliminarily reviews international research on public cultural digitalisation. (1) Based on conceptual definition, it systematically summarises cutting-edge technologies, digital space construction and service models, and identifies future research directions. (2) It constructs a knowledge framework of international public cultural digitalisation, which can serve as an interpretive tool for application scenarios.

Future research could adopt an integrated approach driven by data, methods and theories, combining data intelligence with expert knowledge. Quantitative methods can further explore the mechanisms behind the framework.

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