

Conceptual Models for the Implementation of Mobile Technologies in Cultural Heritage Organizations

Vandy Pacetti-Donelson, EdD

Assistant Professor and Director of the Library/Archivist, United States Sports Academy/The American Sport Museum & Archives, USA

Abstract: Mobile devices have an important role in society in that they have already supplanted other means of information seeking tools as the primary preference for users to find the latest news, entertainment, and educational information. Increasingly, cultural heritage organizations have implemented mobile technologies to provide visitors with an empowered cultural experience. Choosing an adequate formal process for mobile application design and implementation has become an important success requirement. However, there is little, if any, review research analyzing and synthesizing existing models and frameworks for designing mobile cultural heritage environments. This work presents a review, which will categorize and synthesize information from several studies that provide design frameworks or conceptual models in order to implement mobile experiences into the presentations from cultural heritage organizations. This review will provide insights and may inform practitioners as well as mobile application designers and researchers who are interested in providing meaningful mobile learning experiences and environments based on sound theoretical foundations.

Keywords: mobile technologies, cultural heritage, application architecture, conceptual model, design framework, sense making, user experience

1. Introduction

Mobile technologies have changed the way people interact and serve as the preferred devices of information seeking in the last decade. With the significant improvements in Internet connectivity and device portability, consumers have come to expect that there will be an application to meet every need in every location, and that includes when seeking experiences in and from cultural heritage organizations. “Mobile phones are being increasingly used in the context of museums and exhibition spaces, maybe because of their light weight, their increased computational capabilities (which allow embedding interactive applications with rich graphics), or the fact that most people have their own device” (Portalés, Rodrigues, Rodrigues-Gonçalves, Alba & Sebastián, 2018). These devices promise increased engagement helping to bring cultural heritage content closer to the public.

As mobile technologies become ubiquitous in our daily experiences, there is an increasing interest in the development of applications to encourage engagement in every cultural heritage organization, regardless of size, funding, or expertise. The technology sector has responded to this interest with many companies who offer a measure of creation—from basic “do-it-yourself” application builder to a full service development experience leading to a fully packaged and branded mobile application. Cultural heritage organizations find themselves adding research and development of mobile applications to their strategic plans.

Research and development of a mobile application requires many decisions that lead to the development and implementation of a mobile application in cultural heritage programming. These decisions are based in a service dichotomy: what contribution will the application provide the cultural heritage institution and what contribution will the user experience? Decision makers often create conceptual models in order to visualize intentions during the iterative design process. This development has led to a growing body of best practices and literature, and this research seeks to identify trends through content analysis in order to support design and research into mobile applications and provide insightful implications in the creation of meaningful mobile experiences and engagement.

2. Mobile Technologies in Cultural Heritage Organizations

Early mobile technology experiences in cultural heritage organizations began with pre-recorded tours created by curators to guide visitors. Audio guides in museums have been in use since the 1950s. Cassette players were used in the 1960s and radio frequency tour systems were used throughout the 1970s and 1980s. Later, MP3 players allowed users to select which parts of a guide in which to listen.

In 2009, the National Gallery in London launched “Love Art”, a smart phone application featuring hundreds of paintings with commentaries from the collection. Today’s applications feature text, audio, video, virtual reality, user interaction, GPS or “Smart City” technology for enhanced user experiences. Some applications are tied to overall cultural heritage or institutional experience while others focus on specific collections or virtual or virtually assisted exhibit experiences.

From the small limited content museum, archive, or special library to the national museum or library system, mobile applications have been developed on a continuum of complexity, engagement, and expense. According to Aaron Radin, an app developer in an interview with Sam Grobart, the key to a cultural heritage application is not how many features it may have, but the quality of its content. “If it can elegantly and efficiently access that high-quality content, it will be successful” (Grobart, 2011).

“While the library and museum communities are involved in arriving at best practices, it happens for each cultural heritage community at a

different pace, and different issues affect agreement on the best practices. Libraries and museums never see the emergence of a dominant design in commodity or business-practice terms, because each one has unique content to contribute to the digital asset world available through the Web. Therefore, while the entire concept of market consolidation does not apply, best practices emerge through a similar process in both types of organizations” (Bishoff & Allen, 2016).

Frequently, these best practices are communicated through the conceptual models that were developed during the iterative design process and shared with the community of practice in publication or presentation. An analysis of shared conceptual models may communicate the continuum of complexity of mobile applications and the path of development for institutions, large and small, seeking guidance in the research and design process.

3. Conceptual Modelling

Conceptual models are created to communicate the underlying intention or thought process of any applied design process and can be carried out at any stage in the design lifecycle to provide a better understanding. These visualizations form mental models that provide understanding when trying to introduce something new. Intentions and contribution may be mapped when expertise is lacking to define expectations.

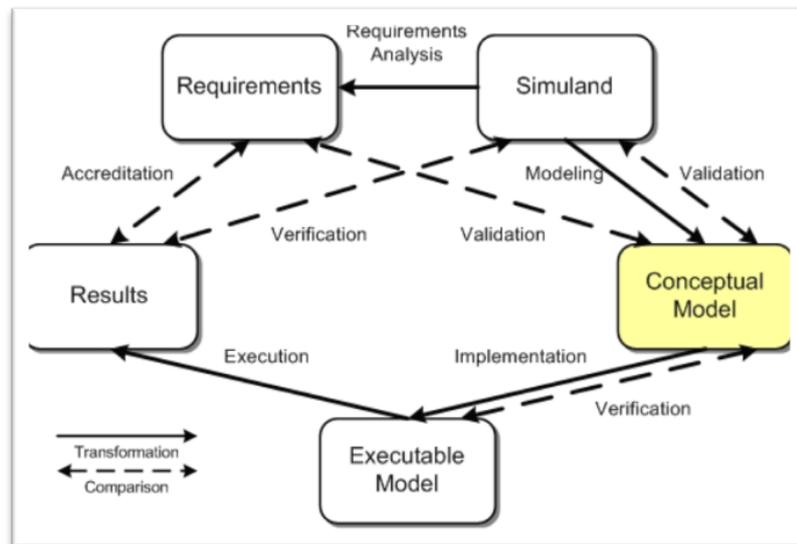


Figure 1: From J. Sokolowski and C. Banks. 2010. Modeling and Simulation Fundamentals: Theoretical Underpinnings and Practical Domains, Wiles, pp. 333.

Typical conceptual models incorporate tasks, objects, and terminology, which are explained in the language of the user, demonstrating recognizable attributes and providing standardization in the design lifecycle. In the development of a conceptual model to visualize application development, best practices may emerge and may demonstrate a “proof of concept” among various application development choices for cultural heritage experiences.

4. Research Method

Data Collection and Article Selection Criteria

While the large cultural heritage organization may have many research sources at their disposal, the small community or independent organization may not have access to typical scholarly research databases to conduct best practices research. According to Borrego (2020), “Research has shown Google Scholar to be reliable and to have good coverage of the diversity of disciplines, languages, and document types in the humanities and the social sciences, where usage of heritage collections is expected to be the highest.” Further, since Google Scholar strictly indexes papers available online, it may provide the access to the best practices decision makers may seek during the research and design process (Martin-Martin, et al., 2018; Gusenbauer, 2019). The sample for this study was collected through a search strategy employing Google Scholar. Four searches were conducted with the following keyword phrases:

- a) “Conceptual model” “mobile application” “cultural heritage”
- b) “Design framework” “mobile technology” “cultural heritage”
- c) “Design framework” for “smart phone apps” smartphone application
- d) “Conceptual model” “cultural heritage” mobile technologies

The timespan was limited to a 5-year range from 2015 to 2019 with the exclusion of patents and citations from the searches. In the initial search, the total items found among the four searches were (n=3,513) with a portion of these articles being excluded due to lack of linked full text article (n=2,569).

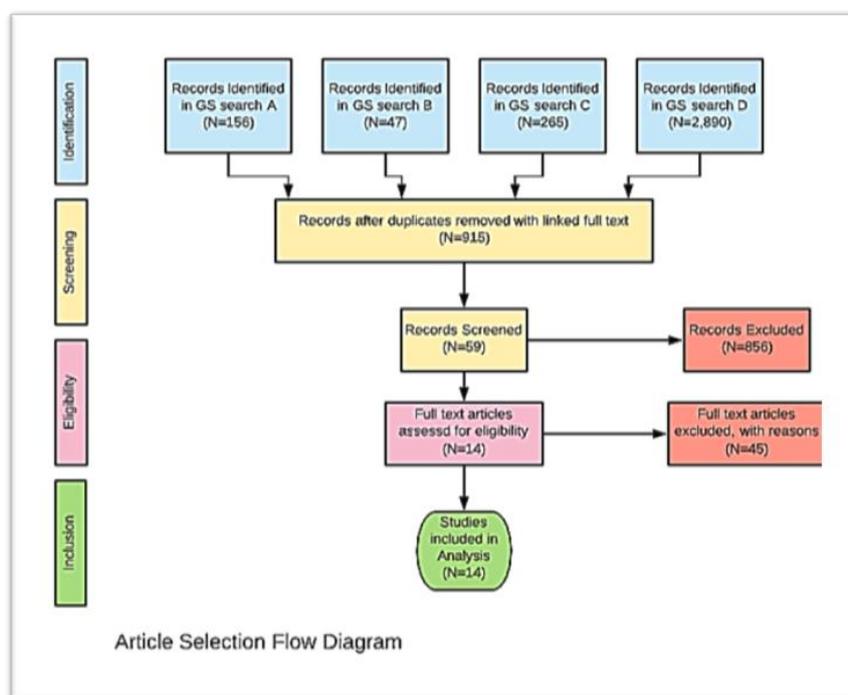


Figure 2: A diagram indicating the selection process for articles included in the present study.

The full text linked articles (n=915) were initially screened for the inclusion of the term “conceptual model” or “design framework” in the Title, Abstract, or Keywords with “cultural heritage” and with duplicates also being removed.

Finally, eligibility of the remaining articles (n=59) was determined by the following set of criteria:

- Articles that did not provide a visual illustration of the conceptual model or framework and/or limited in-depth discussion of the model or framework were also excluded.
- Articles that did not convey whole institution or system focus application development were excluded.
- Articles were excluded from this analysis if the focus was on technical system design (e.g. algorithms) instead of user interface and engagement aspects based on empirical evidence.

The complete article selection process is demonstrated in Figure2. From the original selection of retrieved articles (n=3,513), fourteen articles (n=14), published from 2015 to 2019, were selected for inclusion in this analysis.

Data Analysis

Articles were organized into categories based on purpose and arranged by year and first author. Each article was examined to ensure the existence of a visual presentation of the conceptual model or framework and an in-depth discussion of the same. Table 1 presents articles and the conceptual models that were included and reviewed in this analysis.

Category	Year	Author	Article Title	Proposed Model
Potential Contribution	2017	Larario, Varasano, Turi & Maiellaro	Smart Tirana	Mobile app usefulness to smart and sustainable tourism, through the points of view of tourist and destination.
General Application	2019	Baumgärtner	Conceptualizing a mobile app framework for the museum application domain	Object Data and Application Display
App Architecture	2015	Li & Liew	An interactive user interface prototype design for enhancing on site museum and art gallery experiences through digital technology	System Architecture for Interactive User Interface Design
App Architecture	2016	Valtolina	A storytelling driven framework for cultural heritage dissemination	Architecture of the Storytelling Driven Framework
App Architecture	2017	Wang, van Elzakker, & Kraak	Conceptual design of a mobile application for geography fieldwork learning	Elements of user experience for conceptual design
App Architecture	2019	Pavlova	Conceptual model of a mobile application for educational purposes to help preserve the country's historical heritage and promote the cultural identity of the nation	Conceptual Model of Cultural Heritage Mobile Application
Content & Data Management	2015	Gaiani, Apollonio, & Martini	A design framework for smart cultural objects	Design of an Integrated Data Management

				System for a SCO City
Content & Data Management	2018	Al-Khafaji	The development of a theoretical framework for designing smart and ubiquitous learning environments for outdoor cultural heritage	Illustration of content management
Content & Data Management	2019	Padfield, Kontiza, Bikakis, and Vlachidis	Semantic Representation and location provenance of cultural heritage information: the National Gallery Collection in London	Data Aggregation within National Gallery to Create Application Programming Interface
User Experience with AR/VR	2015	Fabola, Miller, & Fawcett	Exploring the past with Google Cardboard	System Architecture
User Experience with AR/VR	2017	Baker, Bakar, & Zulkifli	Mobile augmented reality elements for museum hearing impaired visitors' engagement	MUX Interactions Platform
Sense-Making	2019	Roy	Framework to guide designing of interactive tools for art galleries	Framework to Guide Designing of Interactive Tools for Art Galleries
Sense-Making	2019	Chu & Mazalek	Embodied engagement with narrative: a design framework for presenting cultural heritage artifacts	Tangible and Embodied Narrative Framework
Sense-Making	2019	Bec, Moyle, Timms, Schaffer, Skavronskaya, & Little	Management of immersive heritage tourism experiences: a conceptual model	Four Stage Conceptual Model of Virtual Heritage Preservation for Tourism Experience

5. Findings

While many cultural heritage organizations employ mobile technology applications, not all institutions have applications that demonstrate parity among organizations. Many institutional applications feature collections and exhibitions through text, audio, video, virtual reality, user interaction, GPS and “Smart City” technologies, or some combination of these features. These conceptual models provide insight into the spectrum of developments in applications across the cultural heritage technological landscape, from the small

independent institution developing its first application, to the national level cultural heritage application.

When embarking on the research and design process, often the first consideration in research and development is not a focus on how to share content with users, but to answer the question, “What possible contribution will this mobile application make for the cultural heritage organization and the user?” According to Lerario, Varasano, diTuri, & Maiellaro (2017), the possible contribution a cultural heritage mobile application may make is providing a marketing strategy for tourism. In this study, sustainable smart tourism and mobile applications are explored in order to determine the usefulness of a mobile application to promote the total heritage of Albania and to improve the negative perception of Albania abroad.

A conceptual model determining usefulness from point of view of the user and the cultural heritage site was developed, as seen in Figure 3. While the conceptual model provides elements of user engagement as features of a possible application, the model’s focus is what these features may contribute to the overall impression of Albania as a quality destination. The authors indicate that this design demonstrates consistency with other studies of application contribution by employing elements of the Unified Theory of Acceptance and Use of Technology (UTAUT). The conceptual model does not indicate how these elements will be created, function, or delivered, but that these elements will be included to serve the overall purpose of the application development, and that is to “re-appropriate heritage from the part of the local community and arouse a careful attitude towards the conservation of cultural assets and their surrounding natural and built environment” (Lerario, et al, 2017).

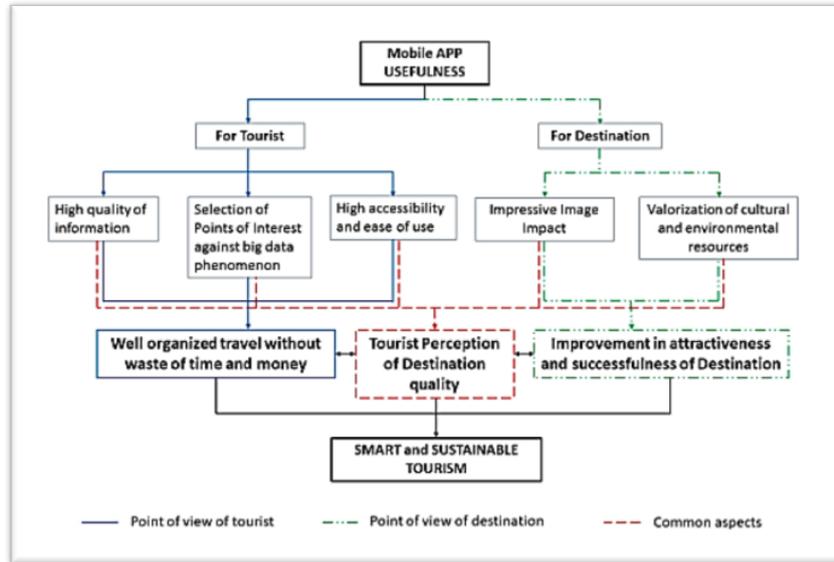


Figure 3: From Lerario, A., Varasano, A., Di Turi, S., & Maiellaro, N. (2017). *Smart Tirana. Sustainability*, 9(12), 2338.

While seeking to make a contribution that will be experienced by the cultural heritage organization and users alike, for the small institution the process of application development must begin at some point. As Baumgaertner (2019) indicates, the cultural heritage application domain provides institutions “the opportunity to deliver their insights to a public audience.” This research acknowledges that the beginning of application development for most institutions of cultural heritage is to transform collection information to digital data. A conceptual framework for sample object data and a visual layout of the application interface is presented in Figure 4. All institutions intent on the development of mobile applications must create systemic digital object data and store it appropriately for access by the user interface. This simple model is a working beginning for all cultural heritage institutions, but especially the small institution looking to begin work on a mobile application employing access to content.

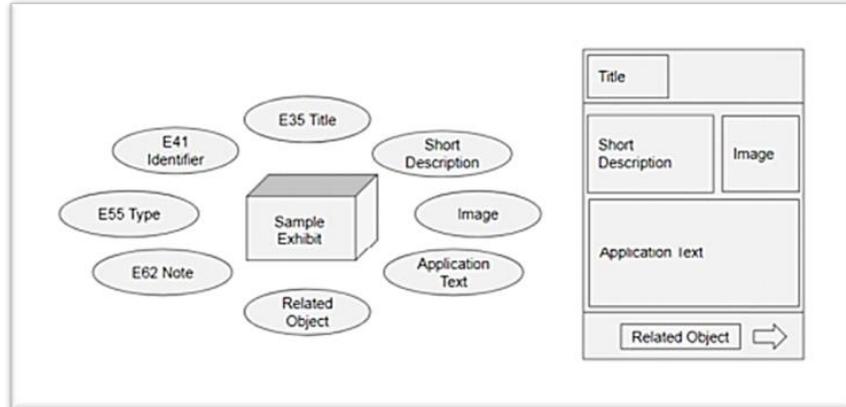


Figure 4: From “Conceptualizing a mobile app framework for the museum application domain,” by T. Baumgartner. 2019, Proceedings of the 27th European Conference on Information Systems (ECIS).

System Architecture

From the creation of digital object data, the focus moves to the development of architecture to deliver content. The conceptual framework in which Li and Liew (2015) developed in Figure 5, demonstrates how this digital data is communicated from storage to device to user. The authors acknowledge that this type of system architecture is most prevalent in mid-sized cultural heritage institutions. This structure is specifically focused on providing an interactive user experience for recommending collection viewing. Semantic keyword searching provided by the user is retrieved from a semantic database to provide the user with a “curated” experience in this model.

This focus on user-centered design may also be seen in the three dimensional conceptual model developed by Wang, van Elzakker, and Kraak (2017) in Figure 6. This model departs from the Li and Liew model in that it represents the contribution aspect as part of the functional processing in the application design.

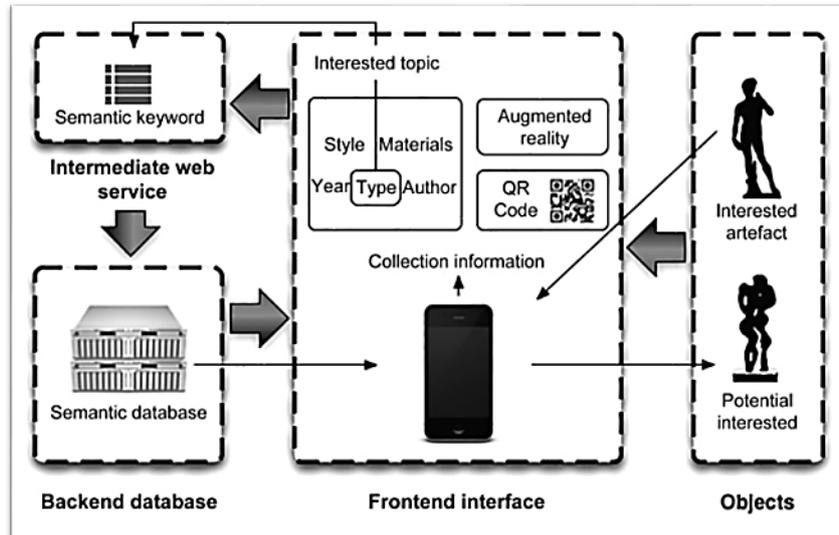
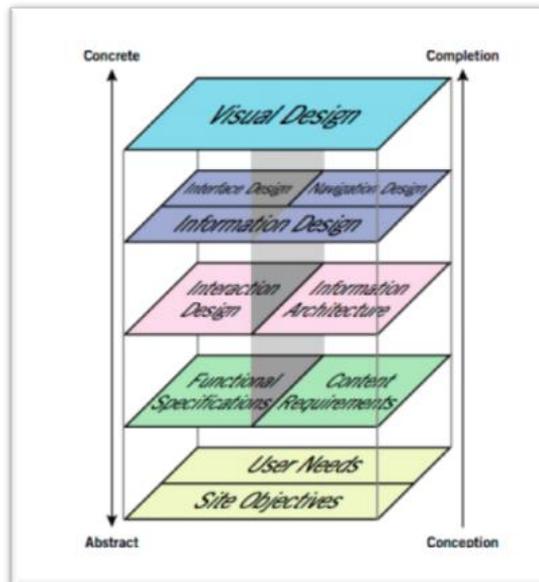


Figure 5: From “An interactive user interface prototype design for enhancing on-site museum and art gallery experience through digital technology,” by R. Y-C. Li & A. W-C. Liew. 2015, *Museum Management and Curatorship*, 30(3), 211.

Figure 6: From Wang, X., Van Elzaker, C. P., & Kraak, M. J. (2017). Conceptual design of a mobile application for geography fieldwork learning. *ISPRS international journal of geo-information*, 6(11), 355.



Valtolina (2016) introduces a new type of framework that allows cultural heritage organizations to share and combine content through ontology-based integration that fosters data sharing. In Figure 7, the main components of the system architecture are visualized in three layers to disseminate information through a story-telling process. The data layer includes the cultural object data with an integration of story data related to the cultural

objects, which communicates with the composition layer. At the composition layer, domain experts employ a graph based authoring tool to create stories and personalization on the presentation layer according to the user’s profile and usage. Over time, collected data from user activity provides new story data to enhance future user experience. Information added through the curatorial process is immediately incorporated into the story telling process as well as providing real-time improvement of user experience.

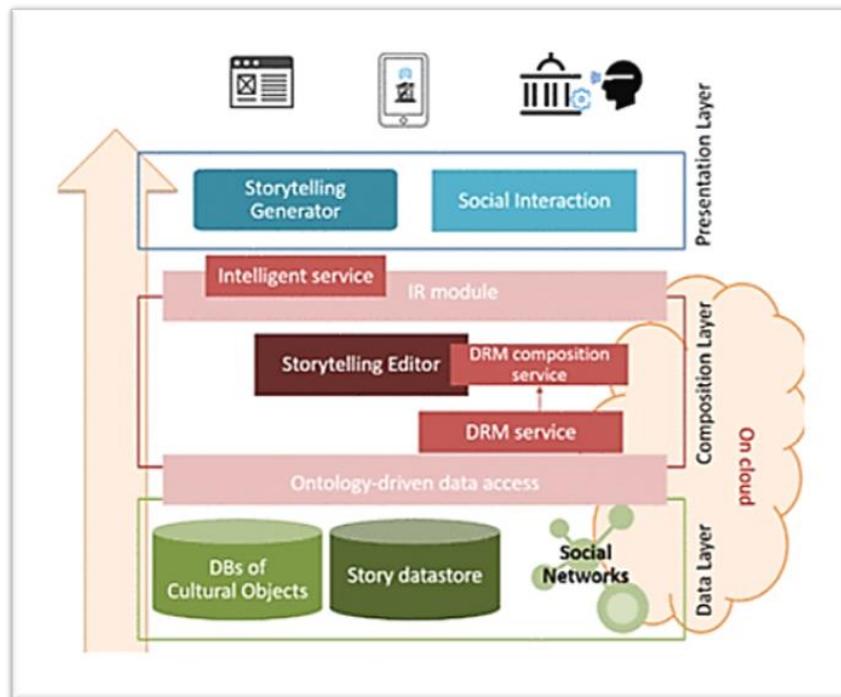


Figure 7: From “A storytelling-driven framework for cultural heritage dissemination,” by S. Valtolina. 2016, *Data Science and Engineering*, 1(2), 119.

Pavlova (2019) demonstrates how system architecture may be constructed with modular elements in order to allow for continued development and improvement without interrupting web services and data exchange among institutions sharing the application. In this model seen in Figure 8, various stakeholders are able to share responsibility for maintenance, improvement, and updates of component modules. This modular approach also allows system storage to be delocalized where multiple institutions may share the load and expenditures. A modular approach also allows for the incorporation of multiple social media platforms and ecommerce applications as module input. The resulting conceptual model was developed to provide a country/system wide cultural landscape that included public/private partnerships.

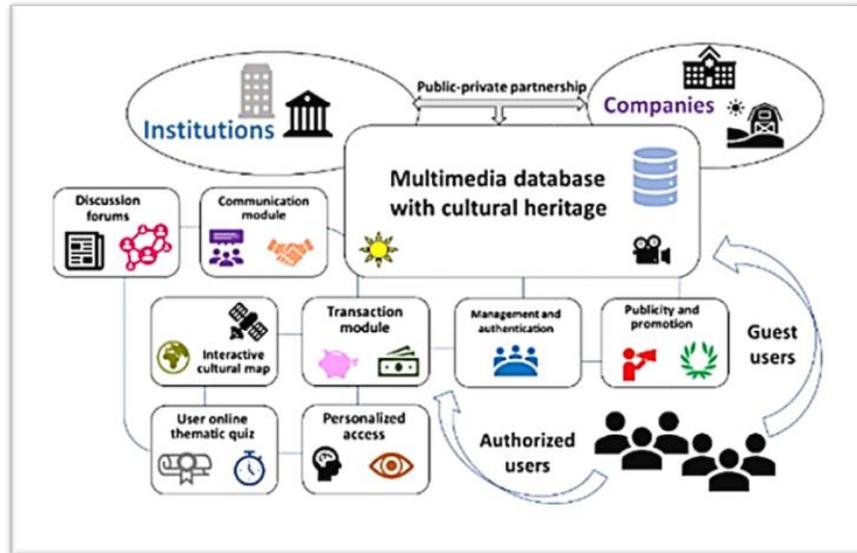


Figure 8: From “Conceptual model of a mobile application for educational purposes to help preserve the country’s historical heritage and promote the cultural identity of the nation,” by D. Pavlova. 2019, Digital Presentation and Preservation of Cultural and Scientific Heritage, p. 299.

Data Management

As more cultural heritage organizations attempt to work together to provide access to their collections for meaningful experiences, a focus on data aggregation and management is necessary. Gaiani, Apollonio, and Martini (2015) developed a framework for the design of an integrated data management system for all cultural objects using semantic location provenance in Figure 9. This framework would allow for access to cultural heritage information at multiple levels of access and information by the variety of users of cultural heritage information so that information can be transformed into new understandings and systems of education that can be accessed on all internet connected devices. The development of this framework would enable data management to serve as content for the construction of an educational system for citizens in urban settings.

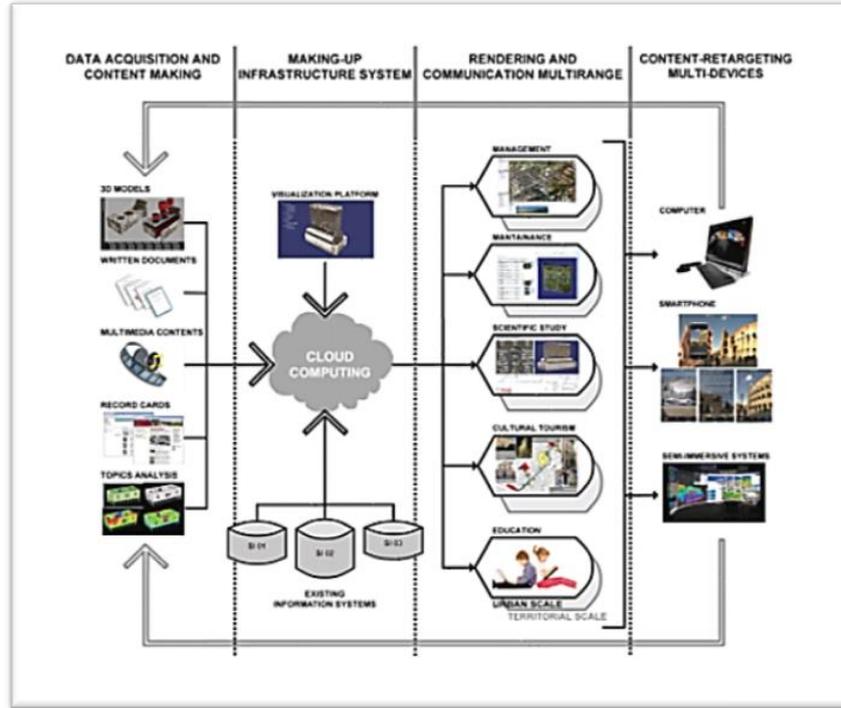


Figure 9: From “A design framework for Smart cultural objects,” by M. Gaiani, F. I. Apollonio, & B. Martini. 2015, *Strategic Design Research Journal*, 8(1), 26.

While Gaiani, et al (2015) propose a conceptual model of how information will be delivered and processed for understanding, AL-Khafaji (2018) proposes the development of an integrated repository of cultural heritage information to be accessed for use in developed mobile applications by the collective cultural heritage community. This proposal would provide curated content in order to free application developers from the concerns of content creation, and whereby some application developers may be limited in their ability to provide content.

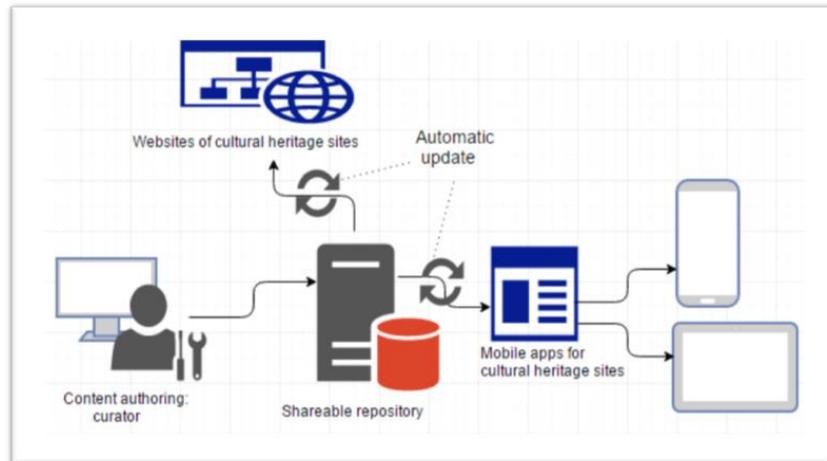


Figure 10: From proposed conceptual model, by Al-Khafaji, A. (2018). The development of a theoretical framework for designing smart and ubiquitous learning environments for outdoor cultural heritage (Doctoral dissertation, University of Portsmouth).

Padfield, Kontiza, Bikakis, and Vlachidis (2019) provide a conceptual model of system architecture to support an integrated data management system for the National Gallery Collection in London in Figure 11. While a discussion of ontology development is made in this article, a simplified, macro level view of the major sources of digital information aggregated within the National Gallery to provide an application-programming interface is provided in the conceptual model that relies on persistent identifiers supplied by international standards for cultural heritage documentation. This application and system architecture allowed for location provenance of all collection information. Further, since standardized identifiers were applied, the digital data could now be supplied to a variety of user applications for different purposes making the collections more relevant at all levels of the cultural heritage landscape from the tourist/experience seeker to the curator/researcher. This is a promising development for the sharing of cultural heritage around the world.

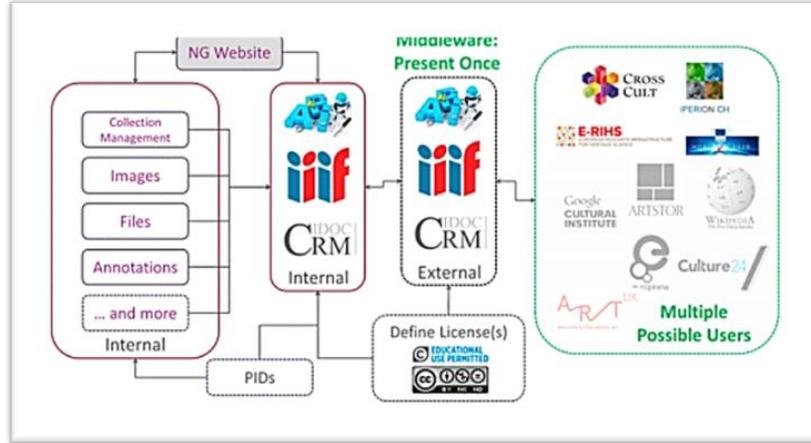


Figure 11: From “Semantic representation and location provenance of cultural heritage information: the National Gallery Collection in London by J. Padfield, K. Lontiza, A. Bikakis, & A. Vlachidis. 2019, *Heritage*, 2(1), 658.

User Experience with AR/VR

Fabola, Miller, and Fawcett (2015) explore the development of a mobile application to provide an immersive on-site exploration of cultural heritage sites. The conceptual model in Figure 12 demonstrates how the application may bring together traditional media into the application augmented by Google Cardboard as mobile device attachment. This application was developed as a complement to a location-aware guided tour application. The figure provides insight into the components of the system workflow. This application design meets the desire for a feature in digital heritage systems that provides the ability to compare past and present states of the area under observation so that the application fosters an appreciation of the locale’s contribution to cultural heritage.

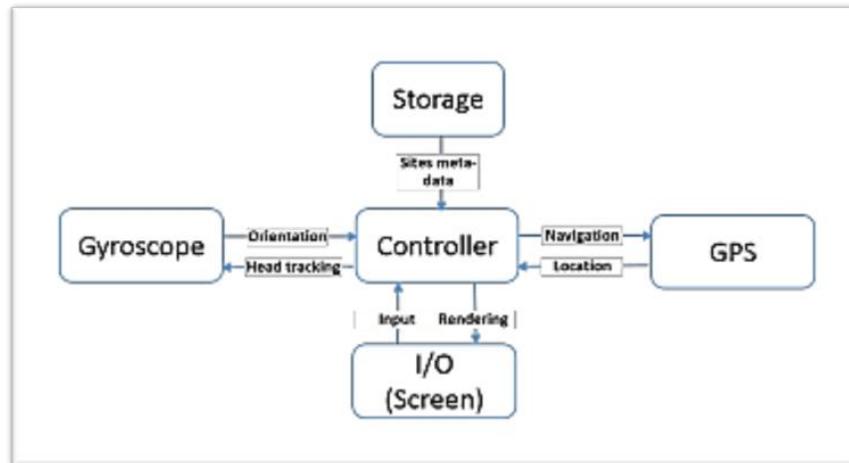


Figure 12:From High level system architecture, by Fabola, A., Miller, A., & Fawcett, R. (2015, October). Exploring the past with Google Cardboard. In 2015 Digital Heritage (Vol. 1, pp. 277-284). IEEE.

As more cultural heritage institutions promote accessibility, there are growing considerations of making augmented reality experiences accessible for the hearing impaired. Baker, Bakar, and Zulkifli (2017) developed a conceptual model to provide insight into the needs of hearing-impaired users. In Figure 13, eleven critical elements are presented for consideration in application development. This model was developed from the findings of ten studies of AR-enabled mobile experiences, which concluded that an effective experience for a hearing-impaired user must be more than the display of text and video. The model is a first step in considering the application design, yet does not provide concrete system architectural developmental suggestions, and may be considered an area of further development for application designers.

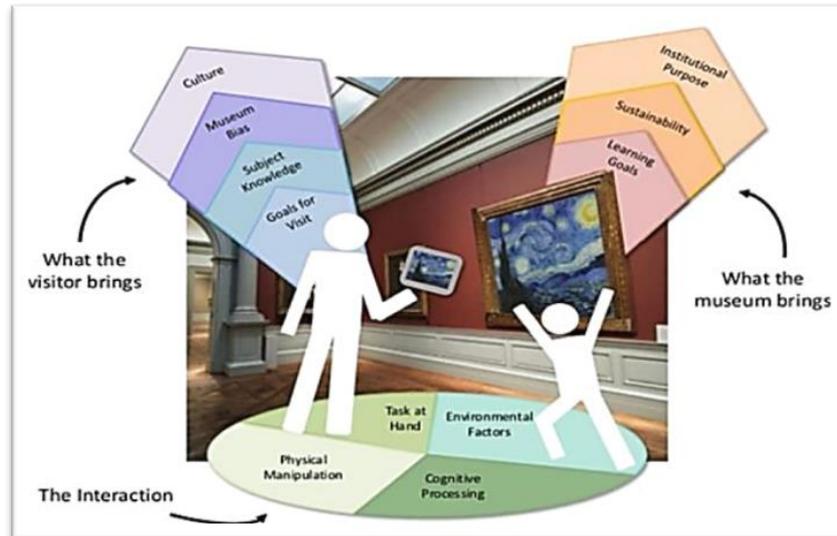


Figure 13: From MUX Interactions Platform, by Baker, E. J., Bakar, J. A. A., & Zulkifli, A. N. (2017). Mobile augmented reality elements for museum hearing-impaired visitors' engagement. *Journal of Telecommunication, Electronic and Computer Engineering*,9(2-12), 171-178.

Sense-Making

While system architecture is a concern for application designers and institutions in the development of first institutional or new exhibition applications for mobile technologies, the present analysis demonstrated an evaluation of conceptual models solely focused on enhancing the user experience in the understanding of cultural heritage. Sense making, or the understanding of cultural heritage in the context of one's personal experience, is the focus of new application technology developments in the field.

Sense making, or the ability to explore and understand information, receives the focus in these conceptual frameworks. The aim is to focus attention on the largely cognitive activity of framing experienced situations as meaningful. The purpose is to shift the curator's role to the backstage to perform supporting activities that would allow users to coordinate their interactions with cultural heritage artifacts for themselves.

Roy (2019) proposed a framework for creating interactive experiences in libraries. Art curators from art galleries in Nova Scotia, Canada were interviewed to determine factors that would influence creation of "tools" for interactive experiences. A design framework to address interactivity was created (Figure 14).

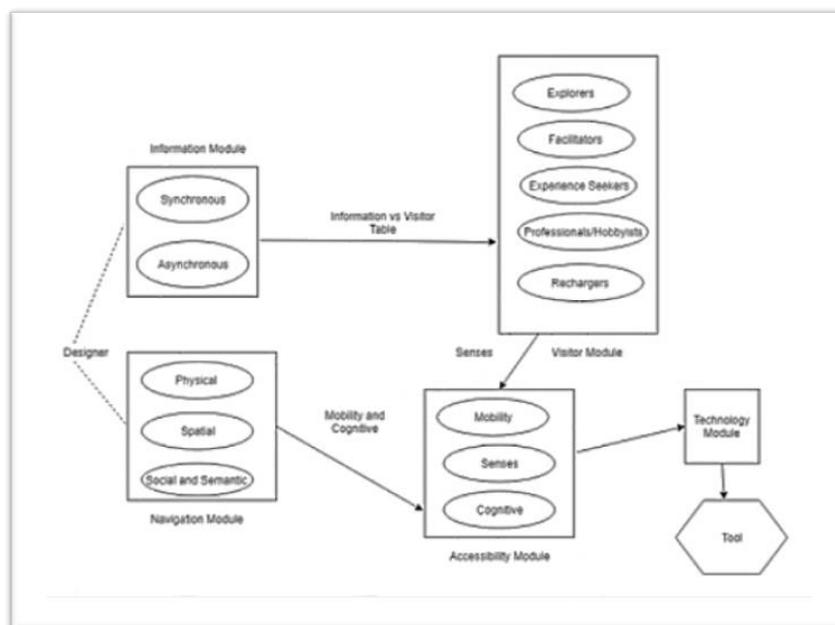


Figure 14: From “Framework to guide designing of interactive tools for art galleries,” by O. Saha Roy. 2019, Master’s Thesis, Dalhousie University.

The framework employed five connected modules that addressed information, visitors, navigation, accessibility, and technology. The information module considered experience from two perspectives, one from a story-telling or guided tour aspect, and the other from the visitor’s preferences and choices for experience. The visitor module employed Falk’s Types of Visitors, e.g. explorers, facilitators, experience seekers, professional/hobbyists, and rechargers. A suggested table of exhibit types based on visitor types was included. The navigation module was further divided into the sub-categories--physical, spatial, and social/semantic. The accessibility module offers the categories--mobility, senses, and cognitive, to address physical navigation in the gallery, sight or hearing impaired visitors, and visitor’s need for engagement, personal connection to content, and self-determination. The technology module, while included in the framework, was excluded from the considerations of the study. The model offers a guiding framework to select technology tools that will individually enrich users experiences based on the needs or desires of the user.

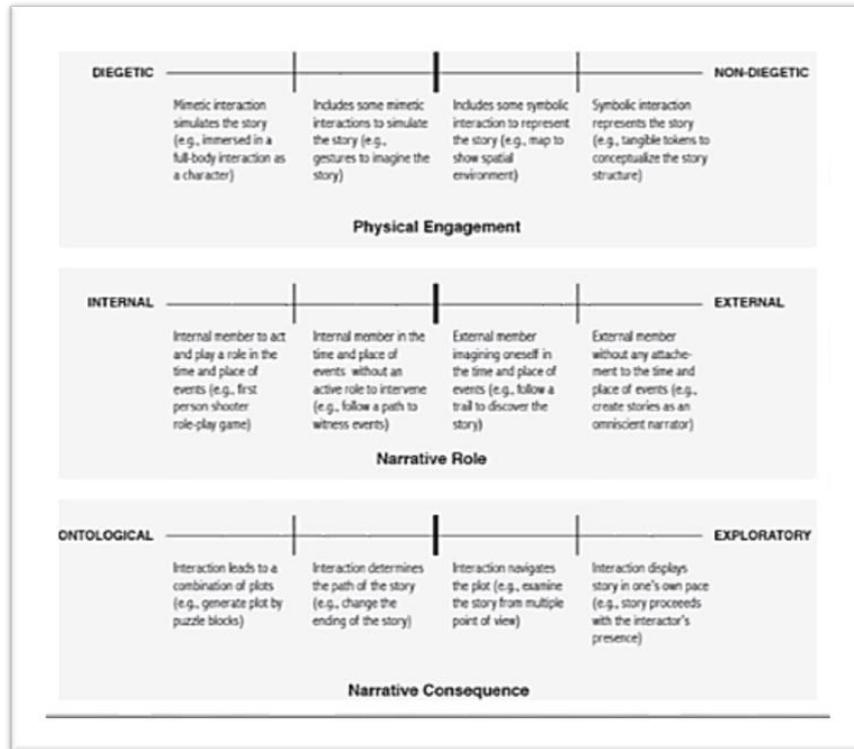


Figure 15: From “Embodied engagement with narrative: a design framework for presenting cultural heritage artifacts,” by J. H. Chu & A. Mazalek. 2019, *Multimodal Technologies and Interaction*, 3(1): 10.

In contrast, Chu and Mazalak (2019) present a framework that focuses on the museum user’s experience seeking behaviors to create engagement with cultural artifacts. This framework proposes that digital media can provide an opportunity for users through their actions to participate in an interactive narrative. Three spectra of behavioral interaction include physical engagement, narrative role, and narrative consequence that embody complex sense-making activities. The conceptual model, seen in Figure 15, provides a decision-making matrix that may assist designers in creating lived experiences for users so that they comprehend the complex meanings and context of cultural artifacts.

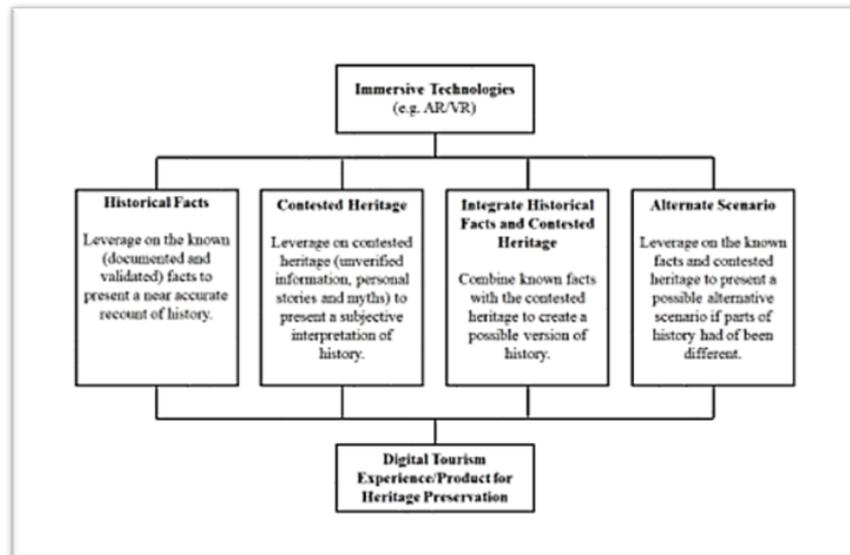


Figure 16: From “Management of immersive heritage tourism experiences: a conceptual model,” by A. Bec, B. Moyle, K. Timms, V. Schaffer, L. Skavronskaya, and C. Little. 2019, *Tourism Management* 72, p. 119.

Another model departs from embodiment to the user’s perspective of cultural heritage and their perception of truth and reality. Cultural heritage often has one story—the one that the curator designs, which places one person’s value system of the cultural heritage experienced as universal truth. Bec, Moyle, Timms, Scaffer, and Skavronskaya (2019) create a four stage conceptual model detailing how cultural heritage and multiple perspectives of that heritage can be used to create multiple contexts of cultural heritage within the tourism experience. The authors indicate that this model will be used to develop prototypes of immersive tourism experiences where the user determines value and personal truth within the cultural heritage experience. Designers may create experiences based on a number of assumptions often unexplored in cultural heritage exhibitions. These explorations provide an opportunity to find personal meaning in cultural heritage experiences and divest users from one universal truth of cultural heritage but to a more personal, lived experience of cultural heritage.

6. Conclusion

“The fusion of tradition, culture, history, and legacy with technology, innovation, and interaction provides an attractive system that serves both as an artistic expression and as a fundamental tool for diffusion in cultural institutions” (Portalés, Rodrigues, Rodrigues-Gonçalves, Alba, and Sebastián, 2018). In the development of mobile applications to share cultural heritage, research and development is key for decision makers. The identification of best

practices may serve as guidance and the identification of sound research is a fundamental step in the process.

Recent conceptual models demonstrate the levels of complexity in which institutions developing applications may be initiated to create applications for cultural heritage experiences. System architecture that provides aggregated data management that maintains provenance is a concern on the forefront of application development. Cultural heritage organizations are also most concerned with the user experience and how cultural heritage is perceived as cultural truth, while still attempting to understand how cultural heritage can be delivered through technological experiences.

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