

Voices Of the Museum: Mobile Audio Storytelling Through MuseumMate

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Abstract—Museums increasingly face challenges in providing inclusive and engaging experiences that accommodate diverse visitor behaviours and learning preferences. Traditional text-based interpretation, while informative, often disrupts the flow of physical museum visits and may impose cognitive load on visitors. This paper presents MuseumMate, an innovative mobile audio storytelling application developed for the Universiti Utara Malaysia (UUM) Management Museum, grounded in human–computer interaction (HCI) and multimedia design principles. The study adopted a design-oriented methodology comprising three phases: requirements analysis, design and development, and formative evaluation. User requirements were identified through semi-structured interviews and on-site observations, revealing a preference for audio-based explanations over lengthy textual descriptions, as well as positive acceptance of audio guides despite limited prior experience. These findings informed the specification of both functional and non-functional requirements, with a focus on usability, performance efficiency, and minimizing interaction complexity. A functional prototype was developed using a low-code platform, integrating professionally narrated audio content with an intuitive, accessible interface. This study contributes practical HCI-oriented design insights into mobile multimedia applications for museums, highlighting the role of audio storytelling in supporting visitor-centred cultural heritage experiences.

Keywords: Museum Audio Guide; Mobile Multimedia; Human–Computer Interaction; Audio Storytelling; Visitor Engagement; Digital Heritage; Accessible Design

1. INTRODUCTION

Museums have long regarded accessibility as a critical concern, traditionally framed in terms of physical access to spaces and artefacts. However, with the rapid integration of digital technologies, particularly web-based and mobile platforms, technological accessibility has become equally significant. Contemporary museum visitors increasingly expect digital support that enhances understanding, engagement, and inclusivity during their visits. As museums shift toward technology-mediated experiences, the challenge extends beyond the removal of physical barriers to the design of digital systems that are intuitive, inclusive, and responsive to diverse visitor needs (Damala et al., 2019).

Since the cultural “memory boom” of the 1990s, museums have re-evaluated how cultural memory and knowledge are communicated to the public. While traditional contextualisation methods such as wall texts, captions, and catalogues remain important, they are inherently static and often require sustained reading effort. In response, museums have increasingly adopted participatory and experience-oriented approaches that actively engage visitors in meaning-making processes (Kumar, 2023). Since then, museums around the world have increasingly adopted a variety of technologies, such as digital audio guides, touchscreen systems, and mobile applications, with recent developments moving toward immersive experiences and AI-driven approaches (Litvark, 2020). Within this shift, audio guides have emerged as a widely adopted interpretive tool, offering visitors an alternative means of accessing contextual information while maintaining a natural flow of exploration.

Audio-based interpretation is particularly valuable in accommodating diverse cognitive preferences and learning needs. Recent research in multimedia learning and cognitive processing demonstrates that many individuals comprehend and retain information more effectively when auditory narration is combined with or used in place of text-based content, especially in informal and experiential learning environments such as museums (Mayer, 2020; Li, 2025). Audio guides can verbalise visual details, animate historical narratives, and reduce the cognitive burden associated with prolonged reading, especially during physical museum visits. In parallel with these developments, contemporary museums increasingly position themselves as visitor-centred institutions that emphasise inclusion, engagement, and audience empowerment (Lynch, 2017). Nevertheless, museums continue to face perceptions of elitism and limited relevance among certain audience groups, underscoring the need for more inclusive and flexible modes of engagement. Within this context, museum audio guide applications play an increasingly important role in supporting inclusive access, enhancing visitor experience, and reshaping how cultural knowledge is communicated.

In heritage and tourism studies, audio guides are widely recognised as central interpretive tools that influence how Advances in mobile technology have further transformed audio guides, shifting them from dedicated rental devices to smartphone-based applications and AI-enhanced systems. This transition enables museums to deliver more personalised interpretive content tailored to visitors’ preferences and contexts. Visitors navigate exhibitions, allocate attention, and construct meaning from displays. Research demonstrates that mobile audio guides can enhance visitor satisfaction, knowledge recall, and intentions to continue using digital guides, particularly when narrative style and emotional arousal are carefully aligned with visitor expectations (Li et al., 2025).

Empirical studies also show that contemporary audio guides support more flexible and self-paced visits by allowing users to select between brief overviews and in-depth narratives, as well as access content in multiple languages and accessibility formats. The adoption of “bring your own device” models (BYOD) lower implementation barriers for smaller institutions and enables real-time data collection on visitor behaviour, such as dwell time and movement patterns,

which can inform ongoing curatorial and design decisions (Gracel & Swacha, 2025). At the same time, several authors caution that content quality remains more critical than interface sophistication; poorly structured interpretive scripts or overly didactic narration can reduce engagement even when delivered through advanced mobile platforms (Roussou & Katifori, 2018).

An audio guide can be utilised without the need for extensive financial investment or the installation of additional hardware within or around exhibition displays. By downloading the audio guide at a single point of entry and using their own devices, visitors are able to explore exhibitions independently (Pireddu, 2022). Interaction with audio guide applications is typically intuitive, as users are already familiar with their personal smartphones. Depending on technical constraints, audio guide systems may be offered fully or partially, often relying on technological infrastructures such as wireless local area networks and radio frequency systems. Some implementations also require the installation of locating devices; nevertheless, audio guides can generally be deployed across multiple locations without the need for costly physical modifications to exhibition spaces.

Despite the growing adoption of mobile audio guides and audio description systems in museum and heritage contexts, existing research has largely concentrated on technological implementation, accessibility compliance, or post-deployment evaluation. Comparatively limited attention has been given to design decisions grounded in empirically elicited user requirements. Many studies frame audio guides as supplementary interpretive tools, offering limited insight into how early-stage requirement analysis informs interface design, interaction flow, and content structuring from a human-computer interaction (HCI) perspective (Damala et al., 2019; Neves, 2020). Furthermore, while audio description research has strongly emphasised accessibility for visitors with visual impairments, fewer studies have examined audio storytelling as a primary interpretive modality for general museum audiences particularly in terms of reducing cognitive load and supporting natural movement during physical visits (Schaeffer-Lacroix et al., 2023). In addition, much of the literature focuses on large national or technologically advanced museums, leaving smaller or institutional museums underrepresented in design-oriented empirical research (Damala et al., 2019; Bian et al., 2025)).

Addressing these gaps, this article focuses on the development of the Universiti Utara Malaysia (UUM) Management Museum Audio Guide Application, an initiative aimed at enhancing visitor engagement through immersive audio-based storytelling. Adopting a requirement-driven, design-oriented approach, the study seeks to identify user needs, translate them into functional and non-functional design specifications, and demonstrate how audio narration can support inclusive, visitor-centred museum experiences. In doing so, the study contributes practical HCI insights into the design of mobile multimedia applications for contemporary museum contexts.

2. RESEARCH METHODOLOGY

2.1 Design Phases

Figure 1 presents the overall methodological flow adopted in the development of multimodal audio guide mobile application named as MuseumMate, which follows three main phases: requirements analysis, design and development, and evaluation. This sequential qualitative approach was selected to ensure that the application was grounded in real museum needs, developed through established design practices, and systematically assessed for quality and effectiveness (Creswell, 2018).

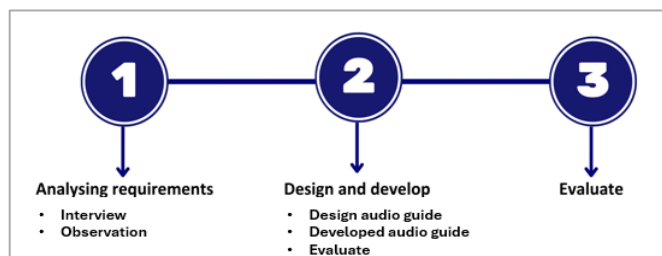


Figure 1. Methods used in developing MuseumMate

Requirements analysis was conducted to understand the functional, non-functional, and contextual needs of a mobile audio guide application within a museum setting. Primary data were gathered through a semi-structured interview with the museum client and on-site observation to capture practical constraints, visitor behaviour, and content expectations. These insights were complemented by a review of related literature on museum audio guides and mobile museum applications, allowing the researchers to identify commonly adopted design patterns and interaction strategies. The integration of empirical findings and prior research informed the specification of key requirements that guided subsequent development (Damala et al., 2019).

The design and development phase focused on translating the identified requirements into a functional prototype of MuseumMate, especially for its user interface and navigation. Particular attention was given to the development of audio description content, which involved researching exhibit information, scripting descriptive narratives, and producing professionally narrated audio recordings. This iterative and content-aware approach reflects established practices in interaction design and accessible multimedia development (Sharp et al., 2019).

Evaluation was conducted to examine the clarity, usefulness, and overall experience of the developed prototype, particularly the audio description component. Feedback was collected from users and domain experts to assess whether the audio content effectively conveyed visual and contextual information and supported visitor understanding. This formative evaluation approach enabled early identification of strengths and areas for improvement, contributing to the refinement of the application and supporting the credibility of the development process.

2.2. Requirement Analysis



The requirement analysis phase was conducted to identify essential design elements and user needs for the development of the UUM Management Museum Audio Guide Application. A qualitative approach was adopted, as it is well suited for exploring users' experiences, expectations, and contextual interactions within cultural heritage settings (Creswell & Poth, 2018). Semi-structured interviews were employed to allow flexibility in probing participants' perspectives while ensuring consistency across respondents. The interview protocol comprised two sections: Section A focused on the interviewees' background and their perception of the museum guide, while Section B examined expectations and functional requirements for the proposed application. Each interview session lasted approximately 30 minutes and was conducted face-to-face with the museum. For these phases, a total of nine respondents participated in the interview sessions.

To complement the interview data, a non-participant observation was carried out on October 2024 at the UUM Management Museum, with prior permission obtained from the museum management. During the observation, visitors from a visual art class and members of the general public were present (no initial meetup was arranged). The observation revealed that most visitors tended to focus on visual artefacts rather than reading textual descriptions displayed on panel boards. They, however, mentioned that the description was important to provide understanding and context about the artefacts. Further informal conversations with several student visitors indicated that they did not prefer long and detailed texts, as they were perceived as unsuitable for physical museum visits, as they disrupted the natural flow of exploration. However, participants expressed a strong interest in receiving explanations through narration while moving around the exhibition space. These insights collectively highlight the need for an audio-based guidance system that supports interpretive storytelling without imposing cognitive overload, reinforcing the relevance of an audio guide application in enhancing visitor engagement and learning experiences within the museum context (Damala et al., 2019)

2.2.1 Interview and Observation Results

Data obtained from the interview and observation phases were systematically tabulated to facilitate clearer interpretation. The analysis was conducted by the primary researcher and subsequently validated by a second researcher to ensure that the data were consistently and systematically captured. The finalised results, presented in Table 1, were then used to inform the design and development of the proposed system.

Table 1. Results From The Interview And Observation

Criteria	Results
Application theme	
Audio/Language(s)	Additional colour: white, background colour:darker Bahasa Malaysia and English
Speaker(s)	Male voice (main), Female voice
Images	Static Images (change when slide)
Type of explanation	Factual + Storytelling (limited)
Interaction styles	Gesture (slide), scrolling for longer information
Interface	Grid styles 
General	The findings also indicate that most respondents were not familiar with museum audio-guide applications and had no prior experience using such systems during actual museum visits. Despite this limited exposure, respondents perceived audio guides as a valuable addition to the museum experience and expressed positive acceptance of the proposed audio museum guide concept.

2.2.2 Functional and non-Functional

Based on the interpreted findings, both functional and non-functional requirements were derived to support an effective museum audio guide system. Functionally, the system must provide structured audio content that aligns with artefact segments and allows users to access information effortlessly while navigating the exhibition space. From a non-functional perspective, usability and performance emerged as critical considerations, as users expressed the need for quick access, minimal interaction steps, and uninterrupted audio playback. The emphasis on intuitive navigation, low cognitive load, and efficient system response reflects the situational context of museum visits, where users are physically mobile and cognitively engaged with exhibits rather than the interface itself (ISO 9241-11, 2018). Details of functional and non-functional requirements can be referred to in Table 2.

Table 2. Audio Museum Guide Functional and Non-Functional Requirements

No.	Functional Requirement
1	Artifacts segments <ul style="list-style-type: none"> a. System will provide a list of segments for users to click and view the list of artefacts on the segment that they choose. b. System will provide a home button for users to click and go back to the list of segments page.
2	To view the artifact images <ul style="list-style-type: none"> a. System will provide a list of artifacts for users to choose and click to view the artifact that they choose. b. System will provide multiple images for users to slide and see the other images
3	To play and pause the audio of the artifact <ul style="list-style-type: none"> a. System will provide the play and pause button for users to click to play or pause the audio description of the artifact. b. System will provide a home button for users to click and go back to the list of segments page.
1	Performance <ul style="list-style-type: none"> a. Audio Response Time - The system shall begin audio playback within 2 seconds after a user selects an artefact or segment. b. Application Loading Time - The system shall fully load the main interface within 5 seconds under normal network conditions
2	Usability Requirements <ul style="list-style-type: none"> a. Ease of Navigation - The system shall enable users to access any audio segment within no more than three interactions (taps) from the home screen. b. Learnability – First-time users shall be able to operate core features of the audio guide without external assistance after a brief introduction. c. Accessibility Support – The system shall provide clear icons, readable text, and adjustable audio volume to accommodate users with different abilities and preferences.

2.2.3 Model Diagram Outcome

The proposed system model (Figure 2) was developed to translate the identified requirements into a coherent interaction structure that supports seamless user engagement. The model positions the user at the centre of the interaction flow, enabling direct access to audio content through simple selection mechanisms while minimising unnecessary system complexity. Core components of the system include content delivery, audio playback control, and user navigation, all designed to operate efficiently within the museum environment. By aligning system processes with real visitor behaviours and contextual constraints identified during the requirement analysis phase, the system model supports an experience that is both technically efficient and experientially meaningful (Sharp et al, 2019).

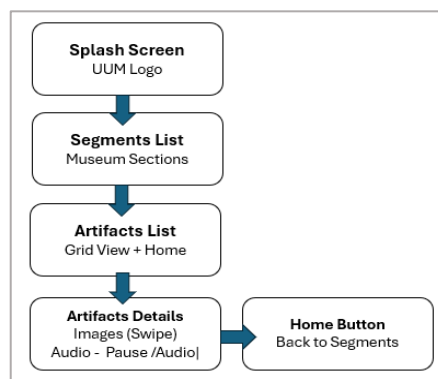


Figure 2. MuseumMate System Model

The core components in Figure 2 illustrate the screen-to-screen navigation map of the UUM Management Museum mobile application. The navigation begins with a splash screen displaying the UUM logo, followed by a segments list

screen. Users can select a segment to access a grid-based list of artefacts. Selecting an artefact leads to a detail screen featuring images and audio descriptions, with navigation controls allowing users to return to the segments list at any time.

2.3 Design and Development

2.3.1 Audio Design

The audio design process began with a thorough examination of the museum exhibits and their associated content. This involved studying the artefacts, understanding their historical and cultural significance, and consolidating relevant information provided by the museum. Building on this foundation, the audio scripts were carefully developed to ensure accuracy, clarity, and narrative coherence, with particular attention given to storytelling elements such as sequencing, tone, and contextual framing. Story-driven audio narration has been shown to support meaning-making, emotional engagement, and sustained attention in museum settings by transforming factual information into immersive interpretive experiences.



Figure 3. MuseumMate Audio design and Development

Once finalised, the scripts were professionally narrated and recorded in a sound studio using high-quality audio equipment to ensure clear and consistent sound output (Figure 3). The recordings were subsequently edited to enhance audio quality and listening comfort. To ensure the effectiveness of the audio descriptions, the recordings were reviewed and tested with both domain experts and potential users, allowing refinements to be made based on iterative feedback. This approach ensured that the audio content delivered rich, descriptive explanations while remaining engaging, accessible, and aligned with visitor-centred storytelling principles in museum interpretation (Damala et al., 2019).

In this application, audio description serves as the core feature, allowing users to select specific exhibitions and listen to in-depth narrations covering visual characteristics, historical background, and contextual relevance. The audio interface also provides playback controls, including fast-forward and rewind functions, enabling users to navigate the narration according to their preferred pace.

2.3.2 User Interface Design

The user interface was designed with a strong emphasis on accessibility, simplicity, and ease of navigation (Al Khalifa & Jiwane, 2025). The application provides a clear and intuitive navigation structure that enables users to quickly access key sections, including the museum introduction, segment listings, and artefact details. Visual design decisions were guided by institutional identity, with UUM corporate colours of dark blue, yellow, black, and white that applied consistently across the interface to reinforce visual coherence and authenticity. Button colours were aligned with the actual colour themes used in the physical museum sections to support spatial and contextual recognition. In addition, simple typography, appropriate font size, and minimal visual clutter were prioritised to reduce cognitive load and improve readability, particularly during in-situ museum use (ISO 9241-11, 2018).

2.3.3 Museummate Application Design

The design and development phase focused on producing a functional prototype that embodied the requirements identified during the requirement analysis stage. Initial development involved the creation of wireframes and conceptual sketches to visualize the overall structure, interaction flow, and core functionalities of the application. The prototype was developed using Adalo, a low-code development platform, enabling rapid iteration and implementation of design features (Saidin, 2024).

Throughout this phase, repeated feedback sessions and informal usability testing were conducted with the client to refine interface elements and system behaviour. Regular team meetings were held to monitor development progress, address technical challenges, and ensure alignment with the intended system requirements. As a result, a functional

prototype was produced and prepared for subsequent usability evaluation and iterative enhancement in later stages of the research (Sharp et al., 2019).

2.3.4 Formative Evaluation

Formative evaluation is a method used to assess the value and effectiveness of a program while it is still under development or in active use. In this study, feedback obtained through formative evaluation was used to inform iterative improvements to the *MuseumMate* audio guide application. During this phase, formative evaluation was conducted through expert interviews involving three specialists: an audio expert, an interface design expert, and a content expert with extensive experience in developing digital museum materials. Each expert was asked to walk through the application and provide detailed comments and recommendations based on their respective areas of expertise.

Based on the feedback gathered from the interviews with the experts, here are some improvements to be made, such as adding a hamburger button in each section's page to ensure a smoother navigation between pages, rearranging the placement of the audio button to ensure that the audio button is visible to the users and a few more. As a result, the new interface we improvised is shown in Figure 4.



Figure 4. MuseumMate Prototype

3. RESULT AND DISCUSSION

3.1 Requirement Analysis: Grounding Audio Storytelling in Visitor Behaviour

The requirement analysis phase played a critical role in shaping the conceptual and functional direction of this *MuseumMate* application. Findings from interviews and on-site observations revealed visitors' preference for audio-based explanations over prolonged textual interpretation, particularly during physical museum visits where sustained reading was perceived as disruptive to the natural flow of exploration. These findings align with prior research highlighting the limitations of text-heavy interpretation in dynamic museum environments and reinforce the value of audio narration as a cognitively lighter alternative that supports continuous movement and situated engagement (Mayer, 2020; Damala et al., 2019). The requirement analysis moved beyond identifying technological needs to uncover contextual and experiential constraints, such as visitors' limited prior exposure to audio guides and their desire for minimal interaction complexity. By explicitly translating observed behaviours and expressed expectations into functional and non-functional requirements, this study demonstrates how requirement analysis can serve as a bridge between visitor-centred insights and practical system design.

3.2 Design and Development: Translating Requirements into Visitor-Centred Interaction

The design and development of *MuseumMate* reflect a deliberate translation of identified requirements into an audio-centred and visitor-oriented interaction that prioritises usability, accessibility, and minimal cognitive load. Design choices such as segmented content, grid-based navigation, and limited interaction steps were directly informed by the requirement analysis, ensuring alignment between visitor expectations and system behaviour. The professional narrated audio storytelling positioned audio as the main interpretive medium, enabling engagement and understanding without prolonged visual focus. This approach addresses gaps in the existing literature, where audio description has been predominantly framed as an accessibility solution rather than a mainstream interpretive strategy for general audiences. The use of a low-code development platform further illustrates how resource-conscious museums can implement mobile audio guides through BYOD strategies, enabling rapid iteration without extensive technical infrastructure. Overall, the design and development phase demonstrates how HCI principles and content-aware multimedia design can be integrated to support inclusive, self-paced museum experiences.

3.3 Formative Evaluation: Refining Design through Expert Insight

The formative evaluation phase provided critical insight into the effectiveness of *MuseumMate*'s design and content while the application was still under development, allowing targeted refinements to be made before broader deployment.

Experts feedback highlighted issues related to navigation consistency, control visibility, and interface clarity, underscoring the importance of formative evaluation in identifying usability and interpretive shortcomings that may not be apparent during internal testing. Notably, evaluative comments reinforced that content quality and narrative structure were more influential on engagement than interface sophistication alone, supporting existing scholarship that cautions against overreliance on technological novelty. Revisions, such as repositioning audio controls and improving the navigation flow, demonstrate how formative evaluation directly contributed to enhancing both usability and interpretive effectiveness. By incorporating perspectives from audio, interface, and digital museum content experts, this evaluation approach strengthened the interdisciplinary validity of the design outcomes. It reaffirmed formative evaluation as a vital component of iterative, HCI-oriented museum application development.

3.4 Implications for Museum Audio Guide Design

Collectively, the findings from the requirement analysis, design and development, and formative evaluation phases highlight the importance of treating audio guides as holistic interpretive systems rather than supplementary digital tools. MuseumMate demonstrates that audio storytelling, when grounded in user requirements, thoughtfully designed, and iteratively evaluated, can support inclusive, self-paced, and cognitively manageable museum experiences. This study contributes practical design insights for museums seeking to adopt mobile audio guides, particularly smaller or institutional museums that are underrepresented in existing research yet face similar challenges in accessibility, engagement, and resource constraints.

4. CONCLUSION

Overall, this study reflects the principle of moving beyond innovation. It demonstrates how human-centred design and accessibility-focused multimedia can be sustainably integrated into museum contexts. This study set out to identify user requirements for a museum audio guide, translate these requirements into functional and non-functional system specifications, and design a prototype that enhances visitor engagement within the UUM Management Museum. The findings from the interview and observation phases directly addressed the first objective by revealing visitors' preferences for concise, audio-based explanations over lengthy textual descriptions, as well as their openness towards adopting audio guide technology despite limited prior experience. These insights provided a grounded understanding of visitor needs and contextual constraints within the museum setting (Al Khalifa & Jiwane, 2025).

In response to these findings, the second objective was achieved through the formulation of clear functional and non-functional requirements that prioritised intuitive navigation, efficient system performance, and minimal cognitive load. These requirements guided the design of an audio-centred interaction model that supports self-paced exploration while preserving the natural flow of physical movement during museum visits. The resulting design reflects a visitor-centred approach that aligns interpretive content delivery with real-world usage contexts.

Finally, the development of a functional prototype fulfilled the third objective by demonstrating how audio narration, simple interface design, and structured content segmentation can be integrated into a cohesive museum audio guide application. While the current study focused on design and development, future work may extend this research through formal usability evaluation, accessibility testing with diverse user groups, and iterative enhancement of interactive features. Overall, this study contributes practical and design-oriented insights into the role of audio guide applications in supporting inclusive, engaging, and accessible museum experiences.

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