DEVELOPMENT OF QR CODE-BASED DIGITAL AUDIO TOURISM AS A CULTURAL EDUCATION MEDIA IN SUMPANG BITA ARCHAEOLOGICAL PARK

Dharu Cahyoaji Sasongko[1)], Jarwinda[2)], Teny Sylvia[3)], Idra Herlina[4)]

[1)]Sains Data, Fakultas Sains, Institut Teknologi Sumatera, Lampung, Indonesia
Email: dharu.123450023@student.itera.ac.id
[2)]Teknik Pertambangan, Fakutas Teknologi Industri, Institut Teknologi Sumatera, Lampung, Indonesia
Email: jarwinda@ta.itera.ac.id
[3)]Teknologi Industri Pertanian, Fakutas Teknologi Industri, Institut Teknologi Sumatera, Lampung, Indonesia
Email: teny.sylvia@tip.itera.ac.id
[4)]Kimia, Fakultas Sains, Institut Teknologi Sumatera, Lampung, Indonesia
Email: idra.herlina@ki.itera.ac.id

Abstract
The Sumpang Bita Archaeological Park in Pangkep Regency, South Sulawesi, is a prehistoric rock art site with important archaeological value, but interpretation facilities are still limited, preventing visitors from gaining adequate contextual understanding. This study aims to develop a QR code-based digital audio tour model as an educational, inclusive, and accessible interpretation medium for the Sumpang Bita Archaeological Park. The methods used included field observations with interviews with 20 visitors, the design of bilingual narrative content (Indonesian-English), and the implementation of the system through the installation of QR Codes at strategic points on the site. Survey results showed that 70% of respondents were unaware of the site's primary historical value, 65% considered supporting facilities very inade quate, and 100% stated that they needed additional guidance. The implementation of the audio tour system has been proven to improve access to information, expand audience reach, including groups with disabilities and speech impairments, and support the trend of digitalization of cultural tourism. While initial trials are limited by their small scale and internet network constraints, this model offers a cost-effective solution that can be replicated at other open archaeological sites. Thus, the development of QR code-based audio tours through the National Community Service Program provides a significant contribution to the preservation of cultural heritage while strengthening the educational experience and community involvement in the conservation of prehistoric sites.

Keywords: Audio Tour, Cultural Education, Digitalization, Qr Code.

Abstrak
Taman Arkeologi Sumpang Bita di Kabupaten Pangkep, Sulawesi Selatan, merupakan situs seni cadas prasejarah yang memiliki nilai arkeologis penting, namun fasilitas interpretasi yang tersedia masih terbatas sehingga pengunjung belum memperoleh pemahaman kontekstual yang memadai. Penelitian ini bertujuan untuk mengembangkan model tur audio digital berbasis QR Code sebagai media interpretasi yang edukatif, inklusif, dan mudah diakses di Taman Arkeologi Sumpang Bita. Metode yang digunakan meliputi observasi lapangan disertai wawancara terhadap 20 pengunjung, perancangan konten narasi dwibahasa (Bahasa Indonesia–Inggris), serta implementasi sistem melalui pemasangan QR Code di titik-titik strategis lokasi. Hasil survei menunjukkan bahwa 70% responden tidak mengetahui nilai sejarah utama situs, 65% menilai fasilitas pendukung sangat tidak memadai, dan 100% menyatakan membutuhkan panduan tambahan. Implementasi sistem tur audio terbukti meningkatkan akses informasi, memperluas jangkauan audiens termasuk kelompok penyandang disabilitas dan hambatan wicara, serta mendukung tren digitalisasi pariwisata budaya. Meskipun uji coba awal masih terbatas oleh skala yang kecil dan kendala jaringan internet, model ini menawarkan solusi hemat biaya yang dapat direplikasi di situs arkeologi terbuka lainnya. Dengan demikian, pengembangan tur audio berbasis QR Code melalui Program Pengabdian kepada Masyarakat Nasional memberikan kontribusi signifikan terhadap pelestarian warisan budaya sekaligus memperkuat pengalaman edukatif dan keterlibatan masyarakat dalam konservasi situs prasejarah.

Keywords: Tur Audio, Pendidikan Budaya, Digitalisasi, QR Code.

INTRODUCTION

Prehistoric cultural heritage serves as a primary source for understanding human identity and the formation of collective memory within society (Susilo et al., 2025). Archaeological sites not only serve as a record of past activities but also serve as a means of cross-generational education, strengthening cultural understanding (Urpi, 2021). Studies in heritage tourism also show that connecting communities with cultural heritage can improve cultural literacy and encourage participation in preservation efforts (Kahidah et al., 2024). Thus, the preservation of prehistoric sites is a crucial strategy for maintaining the continuity of cultural identity amidst modern social change (Chabuk & Al-Amiri, 2023)

The Sumpang Bita Archaeological Park in Pangkep Regency, South Sulawesi, plays a crucial role as an archaeological site preserving prehistoric handprints, footprints, animal depictions, and symbolic engravings. The Maros-Pangkep karst area, where Sumpang Bita is located, has received global recognition through the discovery of a painting of a horned pig at Leang Tedongnge, which is at least 45,500 years old (Brumm et al., 2021). Another discovery, a 39,900-year-old hand stencil at Leang Timpuseng, further strengthens the evidence that Sulawesi rock art is one of the oldest artistic expressions in the world (Oktaviana et al., 2024). Therefore, the significance of Sumpang Bita extends beyond national archaeology, positioning it within the global framework of cultural heritage preservation (Huntley et al., 2021).

Recent analyses have revealed a darkening of pigments in the rock paintings in Maros–Pangkep such as at Leang Tedongnge indicating geochemical accumulation and microbial activity on the painting surfaces, this also underscores the need for a more comprehensive conservation approach (Zhafirah et al., 2024). Furthermore, chemical weathering due to salt crystallization (haloclasty), exacerbated by fluctuating tropical climate conditions, has caused degradation of the rock surfaces and accelerated the loss of detail in the paintings (Huntley et al., 2021). This situation poses a real threat to the region's world cultural heritage, as evidenced by the finding that most of the prehistoric paintings in the Maros caves show signs of advanced deterioration (Gagan et al., 2022). Moreover, ensuring inclusive access to heritage through digital-audio and multisensory guides supports broader engagement, especially for visitors with disabilities, thereby aligning the site's conservation strategy with accessibility and equity goals (Kruczek et al., 2024).

The conservation challenges in Sumpang Bita are not only due to natural factors but also to the lack of interpretive facilities that can help visitors understand the site's cultural value. Recent research suggests that utilizing digital technology, particularly QR codes, can be an effective solution to enrich the visitor's experience and strengthen cultural understanding. A community service study at Kampoeng Heritage Kajoetangan successfully developed a bilingual QR code-based website that is easily accessible and highly engaging for both local and international visitors (Rohani et al., 2024). Similarly, a study in the Sekanak River area of Palembang (Widyawan et al., n.d.) confirmed that QR codes can be a strategic educational tool for developing inclusive and informative heritage tourism. In addition to implementing QR codes, other digital technologies such as digital audio tours and augmented reality (AR) also have significant potential to deepen the visitor experience through immersive narratives and interactive visuals. For example, an AR-based mobile tour guide application with markerless tracking at the Sangiran Archaeological Museum successfully improved information access and facilitated visitor navigation, with a satisfaction score above 90% in an earlier study (Purnomo et al., 2015). At the Bandung Geological Museum, the integration of an AR-based geo-navigation application also proved to facilitate visitors' exploration of the exhibition space and enrich their interactions with the exhibits (Gozali et al., 2024). This approach has led to more inclusive access to information and increased public engagement in cultural heritage preservation, in line with the digital transformation of the global cultural tourism sector. Furthermore, research on digital tourism technology also highlights that QR code and mobile-based systems can enhance tourist engagement and operational efficiency in cultural destinations, serving as practical tools for heritage communication and management (Rozali et al., 2024).

Enhancing inclusive access to cultural knowledge through digital technology, the project supports sustainable education, cultural preservation, and community empowerment (Zhang & Dong, 2024). In the context of the United Nations Sustainable Development Goals (SDGs), Goal 11 "Sustainable Cities and Communities" explicitly emphasises the preservation of cultural and natural heritage (Sharma & Aulakh, 2023). AR presents strategic opportunities to achieve social, economic, and environmental sustainability (Anom et al., 2024). It aims at creating a state of equilibrium across the four interdependent sustainability pillars: economic, environmental, social, and cultural sustainability (El Faouri & Sibley, 2024). AR is used as an interpretive medium that induces experience co-creation among visitors, improving engagement and participation in heritage contexts (Dawis et al., 2024). Together, these studies emphasize that digital innovation in heritage tourism can contribute directly to the realization of SDGs by promoting inclusive learning, sustainable site management, and active community participation. Complementary studies underline that co-design and user-centered approaches are essential for developing inclusive heritage applications, particularly

those integrating voice-driven and interactive features for accessibility (Wang, 2024).

Although QR Code technology has been widely utilized in the tourism sector, its application at open-air archaeological sites in Indonesia rarely integrates comprehensive digital interpretation features. Recent research on audio augmented reality in cultural exploration shows that voice-based narratives can enhance visitors' understanding of heritage artifacts and environments (Cliffe et al., 2019). Similarly, mobile heritage applications that integrate location-based and interpretive storytelling elements have proven effective in enhancing visitor immersion and satisfaction (Ramos Jiménez et al., 2025). This opens up opportunities to design models that not only present information but also provide a more immersive and accessible experience for a diverse audience. To address this need, the author and the National Community Service Program (KKN) XIII team from Balocci Baru 1 Post designed a QR Code-based digital audio tour connected to a bilingual interactive website. The system aims to improve visitors' accessibility to cultural information through voice-guided narratives and contextual interpretation while supporting site administrators in promoting heritage conservation. Content development was conducted through field observations and interviews with visitors and site administrators to ensure accuracy and relevance

METHOD

This community service initiative was conducted as part of the 2025 National Community Service Program XIII, themed *"World Heritage Cultural Tourism as a National Action: Campus Serves and Impacts the Nation"*. The activity took place at the Sumpang Bita Archaeological Park, located in Balocci Baru Village, Pangkep Regency, South Sulawesi, within the UNESCO Global Geopark Maros–Pangkep area. This location was chosen based on the archaeological value of Sumpang Bita as an important prehistoric rock art site as well as the high urgency of preservation and public education. The activity took place on July 8–28, 2025, coinciding with a period of relatively stable tourist visits. The program aligns with the United Nations Sustainable Development Goals (SDGs), particularly Goal 4 (Quality Education), Goal 11 (Sustainable Cities and Communities), and Goal 17 (Partnerships for the Goals). Cultural heritage is recognized as both a driver and an enabler of sustainable development within the *Culture 2030 Indicators* framework (UNESCO, 2019). The project applies this concept by using digital interpretation tools to promote inclusive education and sustainable cultural tourism. Research on digital cultural heritage also shows that participatory collaboration and innovation enhance sustainability outcomes and community empowerment (Aljaafreh et al., 2023).

Initial Observation and Interview

The initial phase involved field observations to assess the physical condition of the site, including the accessibility of visitor routes, available interpretive facilities, potential QR code installation points, and technical challenges such as internet connectivity. Brief interviews were conducted with 20 randomly selected visitors to identify information needs, assess the program's urgency, and understand visitor preferences for digital media in heritage contexts. Applying participatory observation at this stage helped ensure that the resulting design reflected visitors' real experiences and cultural expectations, a method that has been shown to strengthen local engagement in heritage projects (Liu, 2020).

Content Design

Based on observations and interviews, the team designed digital audio tour content with an emphasis on educational, inclusive, and contextual aspects. The narrative materials included the site's history, explanations of archaeological remains such as children's handprints and footprints, interpretations of prehistoric symbols, area maps and tour guides, visiting etiquette that tourists should know, and descriptions of points of interest within the site area. The content is also enriched with information on the ecology and uniqueness of the karst area. The narrative is written in Indonesian and English to reach domestic and international visitors, and to provide accessibility for tourists with disabilities. The script was prepared by referring to supporting literature and the results of field discussions to ensure accuracy and cultural appropriateness.

Website development and QR Code creation

Building upon the results of the observations and interviews, the team developed the digital audio tour content, emphasizing educational, inclusive, and contextual aspects. The narrative materials included the site's history, explanations of archaeological remains such as children's handprints and footprints, interpretations of prehistoric symbols, and descriptions of key points of interest within the park. The content also highlighted ecological information about the Maros-Pangkep karst landscape to connect environmental awareness with cultural interpretation. The bilingual narrative Indonesian and English was designed to increase inclusivity for both domestic and international visitors. This approach reflects best practices in heritage communication design, where multilingual interpretation enhances understanding and accessibility (Privitera et al., 2025). The final script was refined through discussions with site administrators to ensure accuracy and cultural sensitivity In line with recent practices in digital heritage interpretation, integrating panoramic virtual tours and 360-degree visual storytelling

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has been found to significantly enhance accessibility and comprehension for remote visitors (Rahaman et al., 2025)

Initial implementation and testing

The implementation phase involved installing QR Code signs at designated locations. The team then conducted technical trials to ensure code readability, page access speed, and audio quality across various devices. The evaluation process consisted of two stages: a pre-installation phase (interviews with 20 visitors) and a post-installation phase (observation of visitor interactions with the QR Code signage). This feedback served as the basis for further development, both in terms of content and technical aspects. To illustrate the workflow of this project, the overall research process is presented in Figure 1.

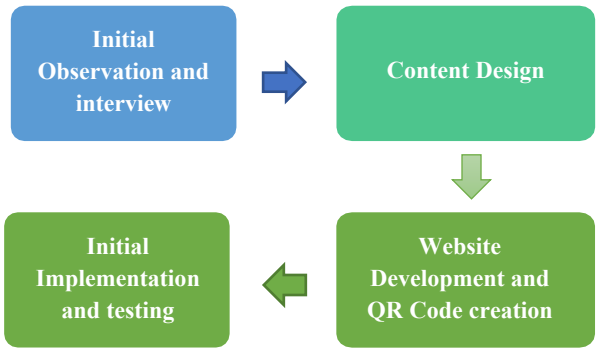

Figure 1. Research Flow

This method has several limitations due to the relatively small scale and short duration of the field implementation, which may not fully reflect long-term performance or user adaptability. Post-installation evaluations were also limited to observational data, without in-depth surveys of visitor experience. In addition, unstable internet connectivity within the site sometimes affected the accessibility of the audio tour. Nevertheless, this initiative demonstrates how small-scale digital heritage projects can serve as adaptable models for sustainable tourism development in Indonesia, aligning with findings from local studies on QR-based cultural interpretation (Widyawan et al., n.d.).

RESULTS AND DISCUSSION

Initial observations at Sumpang Bita Archaeological Park revealed a clear imbalance between the site's strong archaeological potential and the limited quality of available interpretive facilities. Many information boards were faded and difficult to read, visitor trails lacked proper guidance, and unstable internet connectivity left visitors with only a visual experience, without sufficient educational context. These findings support the view of (Nowacki, 2021) who argues that weak interpretive infrastructure can undermine sustainability education and reduce visitors' awareness of cultural value in complex heritage environments. Similar conditions were also identified by (Štrba & Palgutová, 2024), who observed that inadequate interpretation in open-air heritage sites directly decreases visitors' learning effectiveness and engagement with conservation practices. To illustrate these conditions more clearly, Figure 2 presents the visual documentation of Sumpang Bita Archaeological Park during the observation phase.

Figure 2. Condition of Sumpang Bita Archaeological Park

The survey results presented in Figure 3 corroborate these observations. For the first question, regarding the ease of obtaining information before visiting, 10 respondents (50%) gave it a score of 5 (very easy). However, the remainder indicated doubts and obstacles: 7 respondents (35%) gave it a score of 3, 1 respondent (5%) gave it a score of 4, 1 respondent (5%) gave it a score of 2, and 1 respondent (5%) gave it a score of 1 (very difficult). This indicates a significant gap in information distribution, with most visitors still having difficulty accessing basic data about the site. Similar issues have been observed in other heritage destinations that lack integrated digital interpretation systems, where fragmented information flows hinder visitor learning and engagement (Faassen & Hoekstra, 2022). A more serious situation is evident in the third question, regarding the completeness of information available within the site area. Six respondents (30%) rated it as very inadequate (score 1), six respondents (30%) rated it as inadequate (score 2), and seven respondents (35%) rated it as adequate (score 3). Only one respondent (5%) gave it a score of 4, and none rated it as complete (score 5). These findings indicate that the information boards and guides at the site are not yet able to meet visitors' cognitive needs.

In the fourth question, regarding the availability of supporting facilities (maps, signs, accessibility), the majority of respondents also gave a negative assessment. Thirteen respondents (65%) gave a score of 1, two respondents (10%) gave a score of 2, and only five

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respondents (25%) gave a score of 3. None of the respondents gave a score of 4 or 5. This indicates a serious limitation in supporting a comfortable and inclusive tourism experience. Furthermore, the urgent need for guide media is clearly evident in the fifth question. All 20 respondents (100%) gave a score of 5, confirming that visitors need additional guidance to explore the site, either in the form of interpretive signs or an audio tour system. This fact aligns with research findings (Rahardian et al., 2023), which emphasizes that technology-based media can bridge the limitations of physical facilities in conveying cultural information. To illustrate these findings more clearly, Figure 3 below presents the distribution of answers to Q1, Q3, Q4, and Q5 in the form of bar graphs.

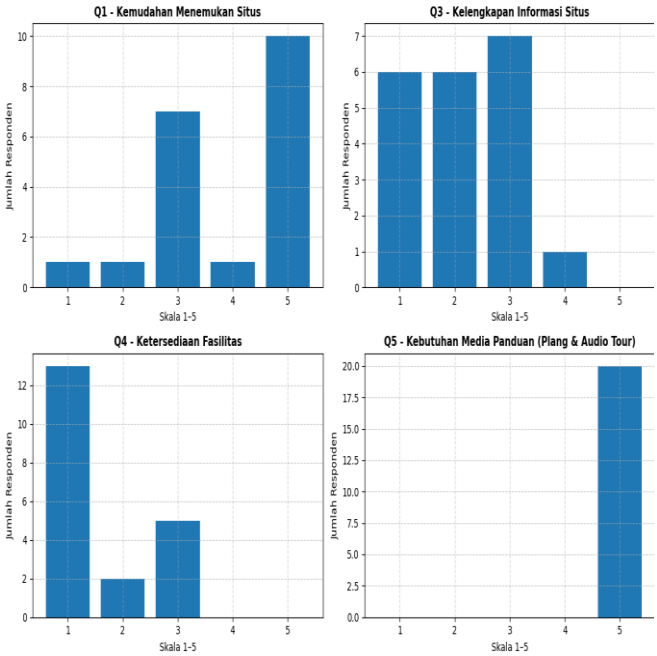

Figure 3. Distribution of answers to Q1, Q3, Q4, and Q5 in the form of a bar graph

The most striking finding emerged from the second question, where 70% of visitors were unaware that Sumpang Bita houses one of the world's oldest prehistoric cave paintings. This fact indicates a serious cultural communication gap, as core information about the site's global historical value is not being properly conveyed to visitors. This condition aligns with research (Widyawan et al., n.d.) which shows that QR Codes can be a strategic tool for conveying essential information about cultural sites to the public quickly and easily. Thus, this survey result underscores the urgency of using digital technology as a more effective interpretative medium. Figure 4 below illustrates the distribution of answers to Q2 in the form of a pie chart.

Figure 4. Distribution of answers to Q2 in the form of a pie chart

To address these needs, a QR Code-based audio tour system was designed as a strategic solution to address interpretation limitations at Sumpang Bita. This technology integrates easy QR Code access with bilingual audio narration (Indonesian and English), thus facilitating not only domestic and international visitors but also providing access for groups with visual impairments and speech impairments. This approach aligns with studies (Cliffe et al., 2019). showing that augmented reality audio and voice-based narration can enhance visitors' understanding of cultural artifacts through a more immersive experience. Furthermore, this model aligns with the global trend of digitalization in cultural tourism, where mobile-based audio guides have been shown to increase visitor engagement and enhance information retention (Nasicha et al., 2025). Figure 5 below presents the installation and inauguration of the QR Code-based Audio Tour Information Board at Sumpang Bita. Recent inclusive digital heritage projects also demonstrate that multisensory and audio descriptive technologies can further improve engagement for visitors with visual or cognitive disabilities (Avni et al., 2025)

Figure 5. Installation and Inauguration of the Audio Tour Information Board

Although initial trials show positive potential, the program still has limitations. First, implementation was carried outon a limited scale and duration, so it cannot yet represent the diverse needs of all visitor segments. Second, limited internet connectivity at the site can hinder the accessibility of audio tours, requiring the development of offline access options in the future. Third, the available audio content is still introductory in nature and cannot fully replace the in-depth interpretation of a professional guide. These limitations align with the findings of (Huntley et al., 2021), who emphasized the need for a multi-layered conservation and interpretation strategy to preserve prehistoric sites and understand them more comprehensively.

Going forward, development can be directed at expanding audio content with multi-level narratives, integrating augmented reality-based visuals, and adding interactive features to enhance visitor engagement. Thus, while still limited, the program's primary contribution remains significant: providing an inclusive, cost-effective, and replicable digital interpretation model for open-air archaeological sites in Indonesia. This strengthens the role of digital technology in addressing cultural conservation challenges and simultaneously encouraging public participation in world heritage preservation.

CONCLUSION

The development of a QR code-based digital audio tour at Sumpang Bita Archaeological Park demonstrates that simple yet strategic technology can effectively address interpretation limitations at open-air archaeological sites. Survey results indicate that visitors generally arrive with minimal prior knowledge, explore with limited facilities and information, and have a clear need for additional interpretive guidance. Through the integration of QR codes and bilingual audio narration, this system successfully provides an inclusive, accessible, and cost-effective model for digital heritage interpretation.The implications of these findings are significant, as they not only strengthen the site's educational function but also support the preservation of world cultural heritage within the framework of sustainable cultural tourism. The integration of smart and adaptive technologies in heritage interpretation can transform visitor experiences and promote the long-term sustainability of cultural sites, aligning with global trends in digital transformation (Ozdemir & Zonah, 2025). Therefore, this study reaffirms the importance of digital technology as a bridge between prehistoric heritage and the needs of modern society, while opening opportunities for replication in other open-air archaeological sites across Indonesia.

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