

PAPER

Augmented Reality Mobile Application for Promoting Culture and Heritage in Thailand and Malaysia: The Prototype Development and Heuristic Evaluation

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ABSTRACT

The global coronavirus pandemic sparked widespread lockdowns and travel restrictions, leading to a significant economic downturn. However, the subsequent development of vaccines prompted governments to ease restrictions and explore technology-driven strategies for tourism revival, including the use of mobile applications and augmented reality (AR). In light of the progress of AR, this study addresses the lack of AR applications for promoting tourism in Southeast Asia, particularly in Thailand and Malaysia, where language barriers hinder cross-cultural communication. Therefore, this study aims to develop a content-specific AR mobile application to enhance tourists' exploration of cultural heritage and facilitate communication in these multicultural and Islamic-influenced regions. This study adopts the design thinking approach for a solution-based methodology. The developed AR mobile application aims to enhance the tourist experience by providing immersive and informative content specific to the culture and heritage. The prototype undergoes a heuristic evaluation by ten experts in human-computer interaction (HCI). The results show a positive consensus on many aspects, highlighting the potential of the AR mobile application to promote culture and heritage effectively. Qualitative exploration through expert feedback is recommended in future studies to refine specific elements for a universally satisfactory user experience.

KEYWORDS

mobile human computer interaction (M-HCI), interaction design (IxD), design thinking approach, augmented reality (AR), prototyping, heuristic evaluation, digital tourism

1 INTRODUCTION

The global coronavirus pandemic, which originated in 2019, has brought about profound transformations across various aspects of life. The virus first emerged in China, leading to the implementation of city lockdown policies. However, its

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continuous spread resulted in the World Health Organization (WHO) declaring a global pandemic in 2020. Governments worldwide responded with extensive measures, including travel, which significantly impacted the economy, education, social interactions, and transportation [1]. The World Travel and Tourism Council reported a 3.7% decline in the sector's contribution to the global economy in 2020 [1]. This situation persisted until 2022, when the development of a vaccine provided a potential solution. While the effectiveness of the vaccine is still debated, it has shown promise in reducing the severity of the virus, prompting governments to relax travel restrictions and explore strategies for economic recovery. During the period of restrictions, technology emerged as a primary communication channel, with individuals becoming more adept at using smart devices. As a result, the travel and tourism sectors are encouraged to utilize technology, such as mobile applications for hotel and flight bookings, to bolster and promote tourism [2]. Augmented reality (AR), which was previously less popular, has gained attention for enhancing cultural experiences, museum visits, and art exhibitions.

Considering the advancement of AR technology, this study conducted a preliminary investigation into the utilization of AR mobile applications for promoting Islamic heritage and culture in Pattani and Malaysia. Interviews and observational approaches were carried out with historians from both countries, and a set of questionnaires on travel preferences was distributed to the public in both countries. This study managed to obtain responses from 400 respondents regarding their travel preferences. The findings indicated a noticeable lack of AR mobile applications for promoting tourism in Southeast Asia, particularly in Thailand and Malaysia, despite their shared history and cultural traits [21] and [24]. Despite cultural ties, language barriers, where Malaysia uses Malay and Thailand uses Thai, pose communication challenges. The decline in fluent Malay speakers in Thailand complicates interactions, potentially hindering the tourist experience. To address this gap, this study focuses on developing a content-specific AR mobile application tailored for tourists in Pattani, Thailand, and Terengganu, Malaysia. The aim is to promote cultural heritage and facilitate cross-cultural communication in these multicultural, Islamic-influenced regions. The study focuses on the development of an AR application for smartphones, a lightweight tool to aid tourists in exploring and understanding the heritage and culture of Pattani and Terengganu. Given the limited availability of content-specific AR mobile applications for Malaysia and Thailand, this study utilizes heuristic evaluation to assess the AR mobile application's potential to support tourism promotion in these two areas by catering to the needs of tourists from both nations.

2 LITERATURE REVIEW

In the literature review section, the discussion covers AR and its application in promoting cultural heritage, with a specific focus on cultural heritage in Malaysia and Thailand. It also delves into the role of AR mobile applications and features customized for tourism applications within AR systems, ensuring a comprehensive exploration of pertinent topics.

2.1 Augmented reality

The pervasive adoption of AR and virtual reality (VR) in recent years has had a profound impact across various domains, facilitated by technological advancements

that enable the simultaneous visualization of real and virtual objects. AR stands out for its ability to seamlessly integrate physical and virtual elements in real-world settings, providing real-time interactivity and concurrent alignment of virtual and physical objects [3]. This results in an AR experience where computer-generated layers enhance visual, aural, and tactile inputs within the actual environment. The study indicates the potential to extend content to human senses, potentially enhancing or even replacing them [4]. Within the context of museums and art exhibitions, AR plays a crucial role in guiding users' attention to cultural artifacts, serving as a medium for communication, disseminating information, and aiding in the interpretation of exhibited concepts [3]. Museums and art spaces have evolved into immersive storytelling environments, significantly influenced by the integration of technology [5].

This study demonstrates how AR technology enhances cultural and heritage experiences by involving users in educational activities and providing comprehensive information through multimedia content. In the fields of culture and history, AR, combined with a multisensory approach that includes sound, narration, lighting, and multiple projections, emerges as a powerful tool for recounting the stories linked to historical and artistic artifacts [22]. Additionally, it can aid in creating thematic visit routes, broadening and streamlining cultural options for users.

2.2 AR technology for the promotion of culture and heritage

Numerous studies have explored edutainment, which is characterized as entertainment with an instructional purpose, to enhance tourist engagement. This innovative approach capitalizes on VR and AR technologies, aiming to integrate diverse learning methodologies for exploring culture and heritage [6]. Noteworthy examples include an AR application developed for archaeological sites in Apulia, featuring superimposed 3D models on aerial images, accompanied by text, photographs, videos, and audio. This mobile application enhances visitors' understanding of historical contexts [7]. Additionally, in the art world, an AR mobile application frames sketches from the Atlantic Codex using a smartphone camera, offering accessible comprehension of Leonardo Da Vinci's creations [8]. Although the Ancient Malacca Project in Malaysia, which concentrates on highlighting Sultan Mansur Syah's era, does not utilize AR technology [9], it aims to enrich visitors' comprehension of cultural heritage, encouraging greater engagement and interaction with history. Furthermore, AR technology uniquely enables the recreation of non-existent spaces, buildings, and monuments, allowing the safe exploration of objects without the risk of damage. It provides a tourist route enriched with superimposed information on points of interest, virtual tour guides, and interactive games overlaying actions on real-world objects, offering enhanced engagement opportunities for tourists [23].

This indicates that the integration of AR technologies, aligned with education principles and various multimedia content, has become a crucial method to enhance tourist engagement and deepen comprehension of cultural heritage. This approach utilizes AR to enrich visitors' understanding of historical contexts, offering innovative and interactive opportunities for engagement in heritage tourism.

2.3 Culture and heritage in Malaysia and Thailand

Current trends in Europe suggest limited adoption of AR technology for heritage applications, while in Malaysia, there is insufficient exploration of heritage

applications aimed at enhancing cultural understanding [10]. However, there exists substantial potential for integrating AR technology into cultural heritage applications for tourism and education in Malaysia, particularly in East Malaysia. This region demonstrates a commitment to constructing and redeveloping various infrastructures reflecting the nation's cultural richness [10]. East Malaysia, with its focus on cultural affirmation, features notable Islamic tourism destinations such as the State Mosque and Islamic Museum in Kelantan, the State Mosque of Pahang, Batu Bersurat, Masjid Abidin, Masjid Tengku Tengah Zaharah, Masjid Kampung Tuan, Kota Lama Duyong, and Islamic Civilization Park in Terengganu [11]. While these locations are renowned, there is room for improvement in fully capitalizing on the potential of Islamic tourism. To enhance visitors' understanding of diverse cultures and heritages, the adoption of AR applications becomes crucial. These applications, offering multisensory content, can create immersive experiences, aiding both Muslim and non-Muslim tourists in exploring historical places and artifacts and fostering a deeper appreciation for the cultural diversity present in these regions.

In regard to Malaysia's cultural richness, Thailand, as a Southeast Asian nation, possesses a wealth of cultural and heritage sites that contribute to the broader tapestry of the region. With its diverse cultural landscape, Thailand has been influenced by Buddhism, Hinduism, and various indigenous traditions, including iconic landmarks such as ancient temples, royal palaces, and vibrant festivals [12]. By offering multisensory content, AR applications can create immersive experiences, allowing visitors to engage more deeply with the rich historical narratives and architectural wonders of Thailand. This technological integration aligns with the broader objective of promoting cultural understanding and appreciation, catering to both local and international tourists alike. As Thailand and Malaysia share cultural similarities and historical connections, the strategic adoption of AR applications can synergistically contribute to a comprehensive exploration and appreciation of the diverse cultural heritages present in the Southeast Asian region.

2.4 Mobile AR

Augmented reality integrates various multimedia data with the real world by overlaying virtual information onto actual objects and locations. This enhances perceptual experiences by superimposing virtual elements onto real environments [13]. Mobile AR specifically refers to AR that is compatible with smart mobile devices, made possible by advancements in mobile, graphics, and wireless technology. Unlike head-mounted displays, pervasive AR systems operate on handheld computers with location-registered technology, such as GPS, making them less obtrusive and more aligned with real-world contexts [13]. Another application involves integrating mixed realities with remote laboratories, allowing users to remotely manipulate both real and virtual devices. A notable example is the Pokemon GO game, a location-based mobile AR game that enhances user experiences by enabling them to capture virtual Pokemon species in their surroundings [14].

Within the tourism sector, the integration of AR with tourist attractions has the potential to enhance tourism experiences by providing a staged alternate reality to visitors. Substantial study since 2016 has focused on AR applications for tourism, with examples such as the NosfeRatu app, an AR game developed for Slovakia's historical

Orava Castle [15]. Additionally, AR is recognized as a dynamic and inventive means to offer enhanced information to visitors in museum settings [16]. Cultural and historical tourism, marked by a surge in international interest, particularly in Asia, where religious and cultural influences profoundly impact daily life, is becoming increasingly competitive. As countries vie to promote their cultural uniqueness and heritage tourism, there is a growing imperative for interactive and effective tourism strategies, with AR emerging as a potential key driver for enhancing visitor experiences. Further investigation is warranted to comprehensively understand how AR applications contribute to the overall visitor experience and influence tourists' behavioral intentions during their cultural and heritage tourism endeavors.

2.5 AR features for tourism application

Augmented reality functions as a visualization technique that superimposes computer-generated data, including text, video, graphics, GPS information, and various multimedia formats, onto real-world images captured through the camera of a computer or mobile device [17]. The goal is to enhance an individual's or domain's perception of the subject matter within a physical environment by blending real-world and virtual elements in a digital information space, resulting in a rich and immersive distribution of knowledge through mixed reality [17]. In the realm of mobile AR, layers of location-based data leverage the user's actual physical environment as a backdrop, setting them apart from the virtual artificial environments typically associated with location-based services (LBS) [18]. Mobile AR applications offer users more interactive experiences compared to other location-based services. Of particular significance is geolocation-based AR, which allows for the virtual preservation of AR elements within the physical environment, accessible to users through their smartphones. This empowers users to navigate specific locations by displaying directions directly over real roadways on their handheld mobile devices [19]. While GPS technology performs similar functions, it lacks the ability to provide an interactive experience, such as offering information on local monuments and points of interest during journeys to specific locations. This limitation becomes especially apparent when encountering monuments or landmarks [19].

Emphasizing their capability to provide detailed information and enhance the overall tourist experience, interactive AR guides highlight the potential for actively developing AR mobile applications dedicated to promoting culture and heritage in Thailand and Malaysia. These applications could leverage the interactive features of AR to provide engaging and informative experiences, making a significant contribution to cultural exploration and tourism in these Southeast Asian nations.

3 RESEARCH METHODOLOGY

The research methodology utilized in this study follows the design thinking approach, a methodology for design that offers a solution-based strategy for addressing user problems [20]. By reframing the issue in human-centric ways, generating multiple solutions in brainstorming sessions, and adopting a hands-on approach in prototyping and testing, design thinking proves highly effective in solving ill-defined

problems and facilitating rapid application development. Therefore, this study employs the design thinking process to propose a suitable solution. The steps are explained as follows:

- Phase 1: Empathize: Empathy is crucial in the human-centered design process of design thinking, allowing researchers to set aside assumptions and gain real insight into users and their needs. In this phase, the study gains an empathetic understanding of the user's problem and explores their challenges. User personas are utilized as tools to visualize the problem for each user, and the information is tabulated in an empathy map that encompasses the user's feelings, pain points, constraints, and goals. Understanding and internalizing the user's problems and needs is critical in this phase.
- Phase 2: Define: In the phase, the study accumulates information gathered in the previous stage. Through analysis and synthesis of the user problem, a core problem is defined, and a problem statement is formulated. To reinforce the problem statement, the study explores and extracts recent literature to review the best solutions for the problem. The study then proposes a feasible solution for the tourist before moving on to the ideation stage.
- Phase 3: Ideate: In this idea phase, the understanding and solid background of knowledge gained from the first two stages trigger out-of-the-box thinking to identify innovative solutions for the specified problem. Considering user requirements, the study identifies suitable content based on the local heritage and culture of Thailand and Malaysia using a user-centered design (UCD) approach. This activity involves collaboration with local people from both countries. The identified content is then transformed and translated into a user interface design with suitable design content elements using a digital storyboard tool. The study proposes a design for a mobile AR application to promote culture and heritage in Thailand and Malaysia as the outcome.
- Phase 4: Prototype: At this stage, the proposed solution is transformed into a high-fidelity prototype using development tools for AR elements and mobile applications. Vuforia is used for developing AR elements, and Unity is employed for mobile applications. The result is a prototype of mobile AR aimed at promoting culture and heritage in Thailand and Malaysia.
- Phase 5: Evaluate: A heuristic evaluation has been conducted to assess the developed prototype. In total, ten experts from Malaysia and Thailand in the relevant field were chosen to evaluate the prototype. Experts were provided with heuristic evaluation forms, and the prototype was physically demonstrated to them. Subsequently, the results from the completed forms were analyzed and discussed.

In conclusion, the utilization of the design thinking methodology in creating an AR solution to promote culture and heritage in Thailand and Malaysia has proven to be a comprehensive and effective approach. By progressing through iterative phases of empathizing, defining, ideating, prototyping, and evaluating, the study effectively tackled user-centric challenges, formulated a clear problem statement, and generated innovative solutions rooted in local cultural contexts. The resulting high-fidelity prototype of a mobile AR application for promoting culture and heritage in Thailand and Malaysia not only integrates the rich heritage content of both countries but also underwent thorough evaluation through heuristic assessment by experts. This comprehensive design process ensures that the proposed AR application aligns with user needs, providing an immersive and culturally sensitive experience for tourists. The project highlights the importance of a human-centered approach and iterative design in developing technology solutions that cater to the diverse cultural contexts of Thailand and Malaysia.

4 PROTOTYPE DEVELOPMENT

The mobile AR application developed in this study aims to promote culture and heritage in Thailand and Malaysia. It is a cutting-edge app designed to provide an immersive and informative experience for tourists and travelers. This app revolutionizes how people explore and interact with the world by offering a dynamic and interactive journey. The development process involves conceptualizing and building a mobile application that enhances the tourist experience through the integration of digital information, graphics, and interactive elements into the physical environment. This complex process includes content design, meticulous application design, careful selection and design of markers, comprehensive application development, the creation of informative brochures, and rigorous testing procedures. These steps are explained below:

- **Content design:** This involves creating or curating digital content to superimpose on the physical environment. It includes developing 3D models, videos, audio guides, text, images, and animations that are tailored to the culture and heritage of Pattani and Terengganu.
- **Application design:** The process involves formulating an intuitive user interface (UI) and user experience (UX) design to facilitate tourists' ease of access and interaction with AR content. This includes designing menus, navigation systems, and on-screen elements to optimize user engagement.
- **Application development:** This phase involves coding the AR application and integrating the chosen AR technology to ensure seamless functionality on the designated devices. Implementation of features such as GPS tracking, object recognition, and marker-based AR is executed to overlay digital content onto the physical surroundings accurately.
- **Informative brochure design:** Designing informative brochures serves as the medium for scanning the AR content. The method utilized in this study for scanning devices is image recognition technology. Through image recognition, users can scan specific images within the brochure using their smartphone camera, triggering the AR content associated with those images. These brochures play a pivotal role in providing users with the necessary information on how to engage with the AR application, offering detailed instructions on scanning, accessing, and navigating the augmented content.

Meanwhile, the key features of the prototype developed in this study are explained as follows:

- **Interactive navigation:** Users can select from a brochure of prominent attractions and utilize the AR marker scanning functionality. Subsequently, the application renders a 3D representation of buildings, locations, videos, images, and supplementary details, with the intent of encouraging physical visits.
- **AR points of interest:** As users engage in exploration, the application identifies and highlights significant landmarks, historical sites, and noteworthy points of interest directly on their device's screen. When users point their devices towards these locations, informational content, including historical facts, trivia, and multimedia components such as images and videos, is presented.
- **Language support:** The AR mobile application designed to promote culture and heritage in Thailand and Malaysia features multilingual capabilities. Users can access information and descriptions in their preferred language, ensuring

accessibility for a global audience. The application supports both Malaysian and Thai languages, enhancing inclusivity.

- Testing: A rigorous testing regimen is undertaken to validate the correct functionality of the application and ensure a cohesive AR experience. Tests encompass compatibility assessments with diverse devices, operating systems, and various network conditions to guarantee consistent and reliable performance.

Moreover, the following paragraph showcases the developed prototype along with exemplary snapshots. The main interface of the application, as shown in Figure 1, displays two interactive buttons, each linked to different geographical locations. Users can choose their desired destination for visiting, thereby enhancing the app’s navigational features. Furthermore, Figure 2 demonstrates how the interface directs users to a compilation of cultural and heritage tourism sites specific to the chosen location. Users can select their preferred destinations by clicking on the respective points of interest. In addition, Figure 3 shows that upon selecting a destination, the interface leads the user to an image representing the chosen location. Finally, Figure 4 details that by clicking on the image related to their chosen destinations, users are taken to an information page offering comprehensive details about the locations. This page provides various functions, including the AR scan feature, a gallery with relevant images of the selected location, a button for GPS tracking, and a button for voice narration in the user’s chosen language.



Fig. 1. Main interface



Fig. 2. Selection of destination



Fig. 3. Chosen location

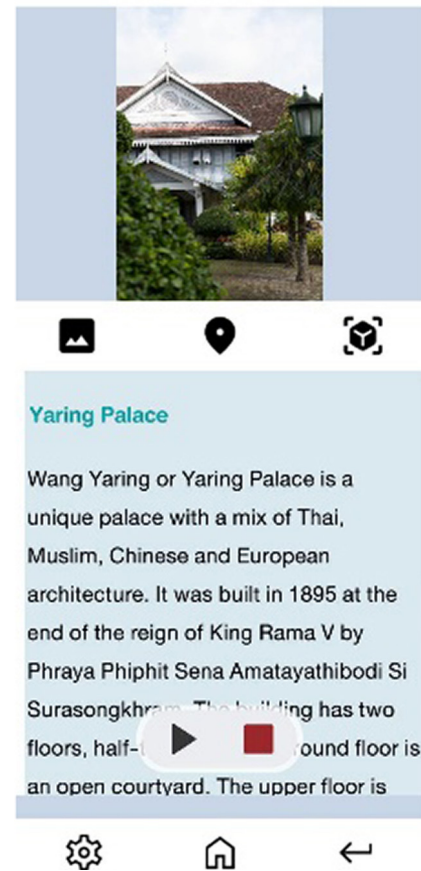


Fig. 4. Information page

5 FINDINGS AND DISCUSSION

This study utilizes heuristic evaluation to assess the usability of a prototype. These heuristics are general guidelines that help identify potential usability issues without the need for extensive user testing. Ten experts from various higher learning institutions were chosen based on their qualifications, each with over 15 years of experience in human-computer interaction (HCI), particularly in the multimedia field. The prototype demonstration was physically shared with these experts, along with instructions and a set of heuristic evaluation questionnaires. The usability assessment focused on nine heuristic criteria: (i) visibility of the system status; (ii) match between the system and the real world; (iii) user control and freedom; (iv) consistency and standardization; (v) recognition rather than recall; (vi) flexibility and efficiency of use; (vii) aesthetic and minimalist design; (viii) visual representation; and (ix) help and documentation. Thirty questionnaires corresponding to the heuristic elements were distributed, using a scale from 1 to 5, where 1 indicated strongly disagree, 2 disagree, 3 not sure, 4 agree, and 5 strongly agree. The results are comprehensively presented and explained for each heuristic element in the form of descriptive feedback.

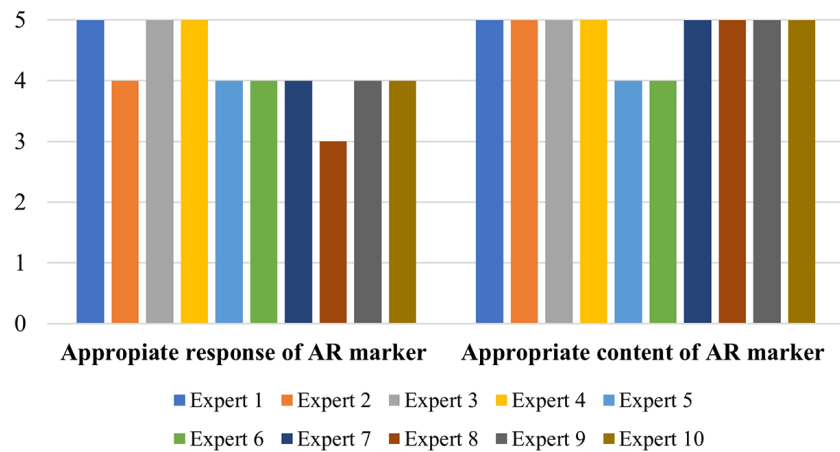


Fig. 5. Visibility of the system status

The heuristic evaluation of the system’s visibility indicates predominantly positive feedback from experts (see Figure 5). Most experts (1, 3, 4, 5, 6, 9, and 10) consistently rated the appropriateness of the AR marker response highly (4 to 5), showing strong consensus. While a few experts (2, 7, and 8) provided slightly lower ratings (3 or 4), the overall sentiment remains favorable, indicating general agreement on the AR markers’ appropriate response. Similarly, all experts unanimously agreed (with ratings from 4 to 5) on the appropriateness of content associated with the AR markers, aligning with the cultural and heritage promotion goals. These findings collectively suggest effective utilization of AR technology to deliver culturally relevant content, with potential divergences in expert expectations warranting qualitative exploration for a more comprehensive understanding of application strengths and areas for improvement.

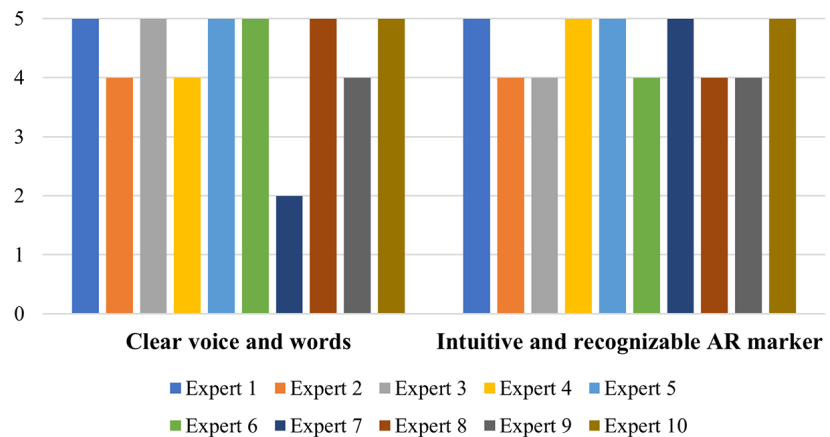


Fig. 6. Match between system and real world

The heuristic evaluation that specifically focuses on the match between the system and the real world, with an emphasis on clear voice and words as well as intuitive and recognizable AR markers, reveals divergent expert opinions (see Figure 6). Experts 1, 3, 5, 6, 8, 9, and 10 consistently assigned high ratings (ranging from 4 to 5) for the clarity of voice and words, indicating a substantial consensus regarding the application’s efficacy in delivering clear auditory information. Conversely, Expert 7 issued a notably lower rating of 2, signaling a significant disparity in their perception of this aspect. Similarly, the appraisal of intuitive and recognizable AR markers garnered positive ratings from the majority of experts (1, 4, 5, 6, 8, 9, and 10),

with scores ranging from 4 to 5, affirming the overall effectiveness of the application in this domain. Nevertheless, Expert 7 assigned a comparatively lower rating of 5, signifying a more critical evaluation. These variations in ratings may be attributed to diverse user expectations, cultural considerations, or distinct interpretations of clarity and intuitiveness. Qualitative feedback exploration is essential to elucidate these differences and gain valuable insights into specific elements requiring refinement for a more universally favorable user experience.

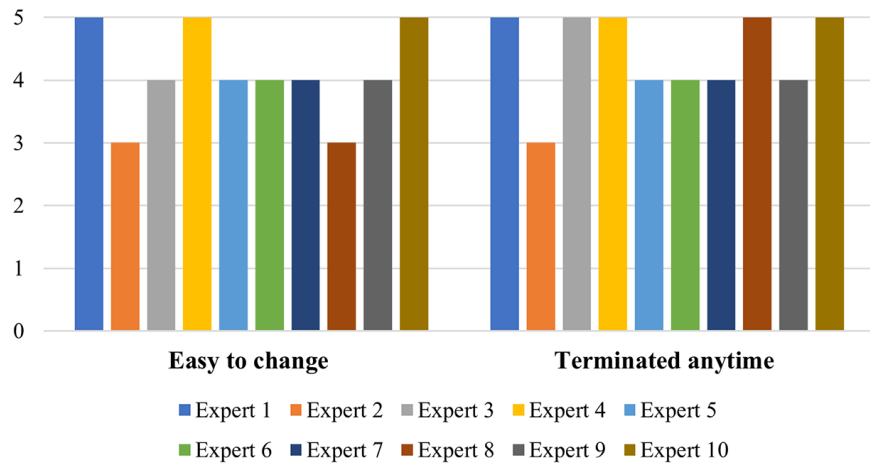


Fig. 7. User freedom and control

The assessment of user freedom and control reflects diverse expert perspectives (Figure 7). In terms of ease of change, experts 1, 4, 5, 6, and 10 provided favorable ratings (4 to 5), indicating a consensus that the application allows users to adjust effortlessly. However, Expert 2 offered a lower rating of 3, suggesting a more critical evaluation of change ease. Similarly, the evaluation of termination flexibility garnered positive scores from most experts (1, 4, 5, 6, 8, 9, and 10), with ratings between 4 and 5, signifying a collective perception that users can terminate the application at their convenience. Nevertheless, Expert 2 and Expert 7 assigned lower ratings of 3 and 4, respectively, implying a more cautious view of the application’s termination controls. These variations may be attributed to differing expectations concerning user control or the specific functionalities deemed crucial for user freedom. Qualitative feedback exploration is warranted to identify areas for potential improvement or clarification to enhance user satisfaction and perceived control.

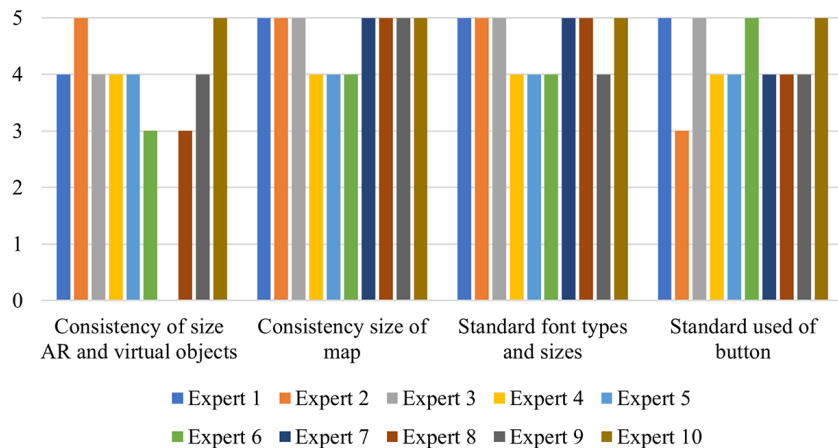


Fig. 8. Consistency and standard

The evaluation of consistency and standardization reveals diverse perspectives from experts (Figure 8). Regarding the consistency of size in AR and virtual objects, opinions differ. Expert 2 gave the highest rating of 5, while Expert 6 and Expert 7 gave lower scores of 3 and no rating, respectively. This divergence indicates varying perspectives on the application’s success in maintaining size consistency. Concerning the map’s size consistency, most experts (1, 2, 3, 4, 5, 6, 8, 9, and 10) provided high ratings (4 to 5), showing a consensus on the application’s success in maintaining uniformity. However, Expert 7 rated this aspect lower with a score of 4, suggesting a more cautious evaluation. In terms of standardization, most experts (1, 2, 3, 4, 5, 6, 8, and 10) agree on the application’s success in maintaining standard font types and sizes, while Expert 9 rated slightly lower with a score of 4. Opinions vary on the standard use of buttons, with Experts 1, 3, 5, 6, and 10 providing positive ratings between 4 and 5, while Expert 2 and Expert 8 rated lower with scores of 3 and 4, respectively, indicating a more critical assessment. These variations emphasize the importance of understanding user expectations and cultural considerations. Qualitative feedback from experts could offer valuable insights into specific areas requiring refinement for a more universally satisfactory user experience.

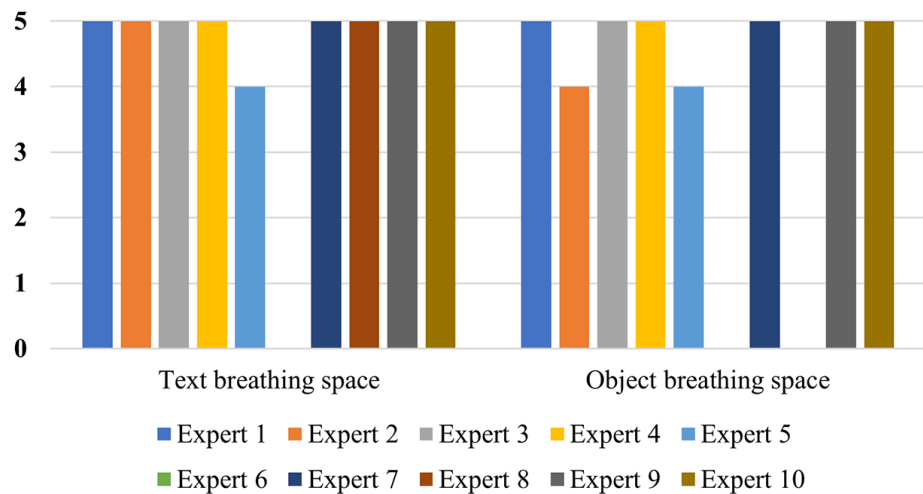


Fig. 9. Recognition rather than recall

The assessment of recognition over recall reveals divergent expert opinions, focusing on text and object spacing (Figure 9). In terms of text spacing, the majority of experts (1, 2, 3, 4, 5, 8, 9, and 10) provided high ratings (4 to 5), indicating a consensus that the application effectively allows sufficient space around text elements for enhanced recognition. However, Expert 6 rated this aspect lower with a score of 0, suggesting a critical evaluation and potential concerns regarding the spacing around text elements. Qualitative feedback is essential to explore specific aspects leading to the lower rating and identify potential enhancements aligned with user expectations. Regarding object spacing, most experts (1, 3, 4, 5, 8, 9, and 10) gave positive ratings between 4 and 5, signifying agreement that the application provides adequate space around objects for clear recognition. However, Experts 2, 6, and 8 assigned lower ratings (4, 0, and 0, respectively), indicating potential concerns or dissatisfaction with the spacing around objects. This emphasizes the importance of understanding users’ specific expectations, with qualitative feedback offering insights into areas that may require refinement for optimal user recognition.

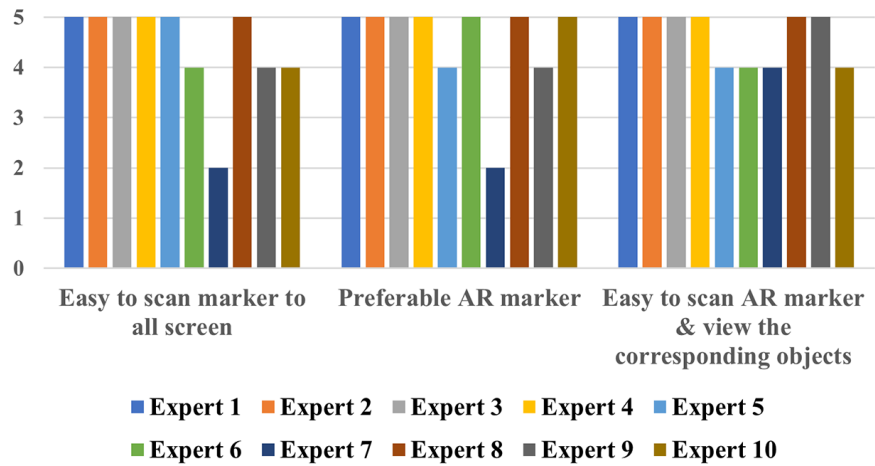


Fig. 10. Flexibility and efficiency of use

The evaluation of flexibility and efficiency indicates positive feedback from most experts (Figure 10). Assessing the ease of scanning markers to access screens, most experts (1, 2, 3, 4, 5, 8, 9, and 10) provided high ratings (4 to 5), signifying a consensus that the application facilitates efficient scanning and navigation across screens. However, Expert 7 gave a lower rating of 2, suggesting potential challenges or concerns with the scanning process. Qualitative feedback from Expert 7 could reveal specific issues and guide improvements for a more universally efficient user experience. Regarding the preference for AR markers and the ease of scanning to view objects, experts generally gave positive ratings (ranging from 4 to 5), indicating agreement that the application offers flexibility and efficiency in interacting with AR markers and accessing associated content. Nonetheless, Expert 6 provided lower ratings (4 and 4) for these aspects, suggesting potential areas for improvement. Exploring Expert 6’s qualitative feedback can offer valuable insights into specific preferences or challenges, facilitating targeted enhancements to ensure optimal flexibility and efficiency for all users.

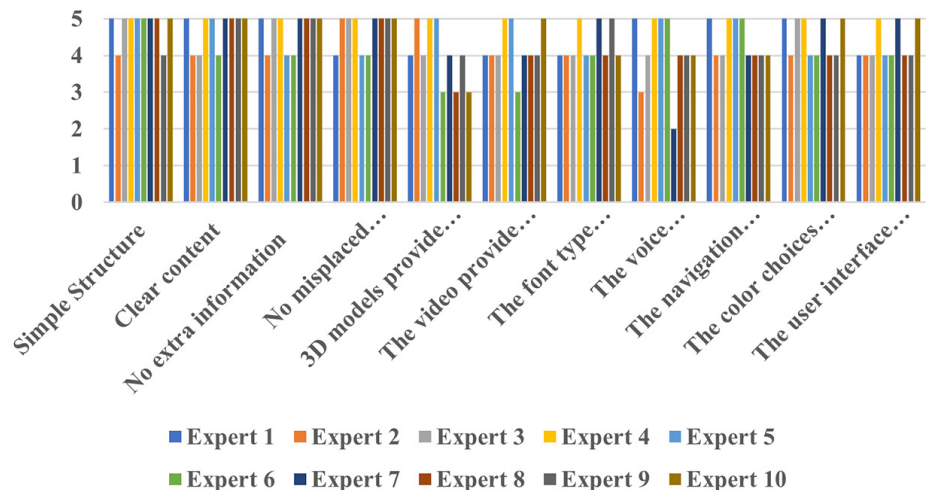


Fig. 11. Aesthetic and minimalist design

The evaluation of aesthetic and minimalist design aspects in the AR mobile application for cultural and heritage promotion in Thailand and Malaysia reflects a generally positive consensus among experts (Figure 11). Across diverse design elements,

including structural simplicity, clear content presentation, absence of extraneous and misplaced information, and the delivery of aesthetic information through 3D models, videos, font types, voice intonation, navigation buttons, color choices, and user interface, most experts (1, 3, 4, 5, 8, 9, and 10) assigned ratings from 4 to 5. These ratings suggest a collective agreement that the application demonstrates an aesthetic and minimalist design, aligning with cultural and heritage promotion goals. However, some variations exist, with Expert 2 providing slightly lower ratings on certain elements. Qualitative feedback from Expert 2 could offer insights into specific design preferences or concerns, guiding targeted refinements for a more universally appealing design. The positive ratings, particularly regarding the provision of aesthetic information through diverse design elements, indicate the successful integration of visual, auditory, and navigational components to enhance the overall user experience. Nonetheless, feedback from Expert 6 and Expert 2 implies potential areas for improvement, and understanding their perspectives through qualitative feedback becomes crucial in refining the application’s aesthetic and minimalist design for optimal user satisfaction.

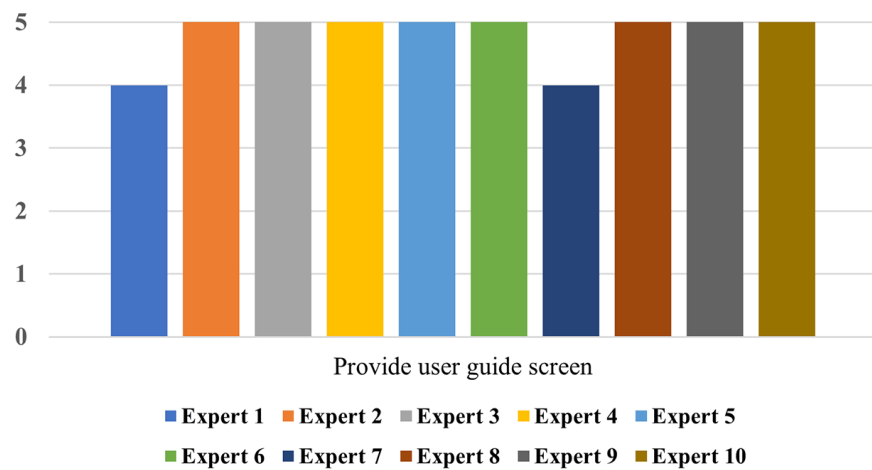


Fig. 12. Visual representation

The assessment of aesthetic and minimalist design aspects demonstrates a generally positive consensus among experts (Figure 12). Evaluating various design elements such as simplicity of structure, clear content presentation, absence of extraneous and misplaced information, and the incorporation of aesthetic information through 3D models, videos, font types, voice intonation, navigation buttons, color choices, and user interface, most experts (1, 3, 4, 5, 8, 9, and 10) consistently assigned ratings from 4 to 5. These ratings indicate an overall agreement that the application exhibits an aesthetic and minimalist design, aligning with the goals of cultural and heritage promotion. Nonetheless, variations exist, with Expert 2 providing slightly lower ratings on specific elements. Qualitative feedback from Expert 2 could provide insights into design preferences or concerns, guiding targeted refinements for a more universally appealing design. The positive ratings, especially regarding the provision of aesthetic information through diverse design elements, signify the successful integration of visual, auditory, and navigational components to enhance the overall user experience. However, feedback from Expert 6 and Expert 2 implies potential areas for improvement, emphasizing the importance of understanding their perspectives through qualitative feedback to refine the AR application’s aesthetic and minimalist design for optimal user satisfaction.

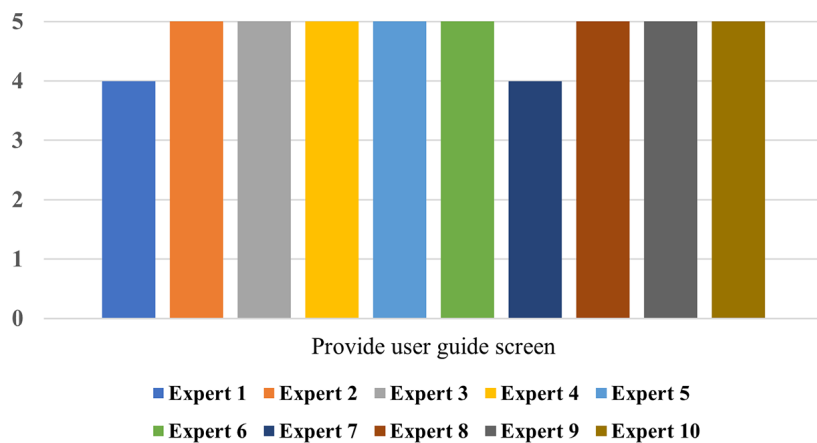


Fig. 13. Help and documentation

The assessment of help and documentation in the heuristic evaluation of the AR mobile application for cultural and heritage promotion in Thailand and Malaysia revolves around the presence of a user guide screen (Figure 13). The majority of experts (1, 3, 4, 5, 8, 9, and 10) assigned positive ratings, ranging from 4 to 5, indicating a consensus that the application effectively incorporates a user guide screen. This consensus suggests that the application provides valuable assistance and documentation, enhancing the user experience by guiding users on how to navigate and interact with the AR features related to cultural and heritage content. The unanimous agreement among these experts emphasizes the significance of clear and accessible documentation in supporting users as they engage with the application. While the feedback is generally positive, obtaining qualitative insights becomes essential to discern specific aspects deemed helpful by users and identify areas for potential enhancements. Overall, the positive ratings affirm the user guide screen's efficacy in aiding users and contributing to a more user-friendly experience in the realm of cultural and heritage promotion through augmented reality.

Overall, the heuristic evaluation presented in this study constitutes a methodologically rigorous examination, offering a comprehensive understanding of the usability of the prototype based on descriptive feedback from expert evaluators. The discerned divergences in expert ratings highlight the necessity for further qualitative exploration to elucidate diverse perspectives, providing valuable insights essential for the refinement of the mobile AR application. This iterative refinement process is paramount to enhancing user satisfaction, especially within the specific contextual framework of cultural and heritage promotion in Thailand and Malaysia.

6 CONCLUSION

In conclusion, this study effectively addressed the deficiency of AR mobile applications for promoting tourism in Southeast Asia, specifically in Thailand and Malaysia, where language barriers impede cross-cultural communication. By adopting the Design Thinking approach, the study successfully developed a cutting-edge AR mobile application designed to promote and enrich the cultural heritage experience for tourists in Pattani, Thailand, and Terengganu, Malaysia. The prototype of the AR application incorporates key features such as interactive navigation, AR points of interest, language support, and meticulous testing, showcasing a comprehensive approach to fostering a meaningful and immersive tourist experience. The heuristic

evaluation conducted by experts in HCI yields generally positive results, indicating that the application effectively addresses crucial usability criteria. However, divergent expert opinions highlight the importance of qualitative feedback to understand specific user expectations, cultural considerations, and areas requiring refinement for optimal user satisfaction. The positive consensus on aspects such as system visibility, content relevance, and user control affirms the potential of the AR application to bridge the cultural and linguistic gaps in promoting tourism. The inclusion of multilingual support, clear documentation, and an aesthetically pleasing design further enhances the user experience. The study's findings suggest that technology, particularly AR applications, can play a pivotal role in revitalizing the travel and tourism sectors, serving as a catalyst for economic recovery and cross-cultural understanding. In moving forward, it is recommended to leverage expert feedback for targeted refinements, ensuring that the AR application aligns with diverse user expectations. Additionally, collaboration with local communities and continuous adaptation to evolving travel trends will be essential for the sustained success and relevance of such technological interventions in the post-pandemic era. Overall, this study lays the foundation for further exploration and development of technology-driven solutions to enhance cultural tourism experiences in the dynamically evolving landscape of global travel.

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