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SMART ACCESSIBILITY IN MELAKA’S HERITAGE BUILDINGS FOR PERSONS WITH DISABILITIES: A TECHNOLOGY-DRIVEN APPROACH

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Abstract

This study investigates the accessibility of public heritage buildings in Melaka for persons with disabilities (PwDs). Despite Melaka’s designation as a UNESCO World Heritage Site, many heritage buildings remain inaccessible due to historical architectural designs that do not meet modern accessibility standards. Employing semi-structured interviews with PwDs and a review of local and international literature, the research identifies key challenges, including inaccessible ramps, narrow doorways, inaccessible toilets, and low staff awareness. The study also explores the potential of integrating adaptive technologies, such as mobile applications and virtual reality (VR), alongside Universal Design (UD) principles. Findings indicate that combining physical upgrades with digital solutions can significantly enhance accessibility while preserving historical authenticity. By addressing these issues, the study contributes to Sustainable Development Goals (SDG), i.e., SDG 10 (Reduced Inequalities), SDG 11 (Sustainable Cities and Communities), and SDG 9 (Industry, Innovation, and Infrastructure), promoting inclusive heritage tourism and ensuring equitable access to Malaysia’s rich cultural heritage. The study concludes with actionable strategies for local authorities and stakeholders to foster a more inclusive and accessible artistic environment.

Keywords: persons with disabilities (PwDs), heritage buildings, smart accessibility, sustainable development goals, universal design, technology

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INTRODUCTION

Heritage tourism is a rapidly growing segment of the global tourism industry, offering visitors the opportunity to explore a destination's cultural and historical landmarks (Geçikli et al. 2024). As a designated UNESCO World Heritage Site (Amir et al. 2015; UNESCO no date), Melaka boasts a profound cultural and historical heritage that attracts a significant influx of tourists each year. Since receiving UNESCO's recognition, Melaka has become a central designation for both domestic and international tourists, recording 13.711 million tourists in 2012 (Amir et al. 2015). Ensuring that all tourists, particularly PwDs, can fully experience these heritage landmarks is therefore of paramount importance. The United Nations Convention on the Rights of Persons with Disabilities (CRPD) emphasizes that people with disabilities should have equal access to cultural heritage sites, just like all other members of society (Equality Act 2010). Despite this, many PwDs reported dissatisfaction with the facilities provided at heritage buildings, including public toilets, transportation infrastructure, services, hotel management, and information maps, which often fail to meet their accessibility needs (Ang Kean Hua 2019). To attract a wider range of local and international tourists, it is essential to provide high-quality services, facilities, and accessible environments that cater to both tourists with and without impairments. Accessible heritage tourism not only fosters inclusivity but also enhances the overall visitor experience and promotes Malaysia's rich cultural heritage. Heritage buildings have gained popularity due to their historical significance, architectural value, and cultural knowledge, attracting tourists eager to explore them. However, accessing these sites remains challenging for PwDs due to physical, informational, and attitudinal barriers. Often, the presence and needs of visitors with disabilities are overlooked when discussing accessibility (Nurul Fadzila Zahari et al. 2023). Urban planning and heritage site design frequently prioritize the general population, neglecting the specific requirements of PwDs. Consequently, PwDs have fewer opportunities to engage in tourism and cultural activities (Ikhwan Ali Wazani, Diana Mohamad & Mastura Jaafar 2021). Moreover, most historic heritage sites were constructed before the establishment of accessibility standards and disability rights. As a result, these sites were not originally designed to accommodate PwDs, who continue to face significant physical and social barriers (Ruiz-Rodrigo et al. 2024). Lastly, PwDs have expressed dissatisfaction with the existing facilities, which include public restrooms, transportation, and insufficient accommodations by site management. Many believe that instead of relying solely on basic disability amenities, public facilities should be modernized and enhanced to provide more advanced accessibility solutions (Ang Kean Hua 2019).

LITERATURE REVIEW

Public Heritage Buildings in Melaka

The preservation and conservation of Malaysia's cultural heritage are governed by the National Heritage Act 2005 (Act 645). This legislation covers national treasures, underwater cultural heritage, natural heritage, tangible and intangible cultural heritage, and other related matters. According to the Act, the term heritage broadly encompasses national heritage, including sites, objects, and underwater cultural assets, regardless of their listing in the National Heritage Register. A building is defined as a structure, or a group of connected or separate structures, that possesses outstanding universal value in terms of history, art, or science due to architectural significance (National Heritage Act 2005 no date). For a building to qualify as an archaeological relic, it must be at least 50 years old (Clause 2.1), encompassing preserved remnants of past landscapes, vegetation, structures, artifacts, and site features. To be gazetted as a heritage building, a structure must meet criteria outlined in Clause 67 of the Act, including historical significance, architectural or aesthetic value, technical achievements, social or cultural associations, educational or research potential, uniqueness, and representativeness (National Heritage Act 2005, Clause 67). The Commissioner ensures that all declared heritage sites are officially listed in the National Heritage Register (Clause 71) and maintains public access under specified conditions (Clause 23). To educate future generations about Malaysia's rich historical background, promote conservation-friendly practices, and enhance community awareness regarding built heritage, Jabatan Warisan Negara (JWN) and Badan Warisan Malaysia (BWM) plays a crucial role.

Melaka, situated on the southwest coast of Peninsular Malaysia in the Strait of Malacca, comprises three districts: Melaka Tengah, Alor Gajah, and Jasin, covering an area of 1,658 square kilometers. The state is accessible by car from Kuala Lumpur (approximately two hours) and Singapore (approximately three hours). Jabatan Warisan Negara (2008) notes that Melaka and George Town are the historical cities that have developed over more than 500 years through trade activities and cultural exchanges between the East and the West. Its rich historical background has made Melaka a prominent tourist destination (Amir et al. 2015). Melaka's public heritage buildings reflect the influence of Portuguese (1511), Dutch (1641), and British (1824) colonization, with the latter being the longest period of foreign rule (Dutch Trading Post Heritage Network 2021). Historically, Melaka served as a major trading port connecting Arabia, China, India, and Europe, facilitating the exchange of goods such as porcelain, silk, spices, and gold (Tourism Melaka no date). UNESCO formally recognized Melaka as a World Heritage Site on July 7, 2008, highlighting over 500 years of East-West trade and cultural interactions along the Straits of Melaka (Amir et al. 2015). This historical significance makes Melaka an ideal case study for assessing

accessibility in heritage sites. Additionally, the Persons with Disabilities Act 2008 (Clause 26, Subsection 2) mandates that facilities for PWD conform to Universal Design (UD) principles, ensuring accessibility and usability for all.

Persons with Disabilities (PWDs)

PwDs in Malaysia are classified into seven categories under the Persons with Disabilities Act 2008 (Act 685), namely hearing, visual, speech, physical, learning, mental, and multiple disabilities. In 2024, the Department of Statistics Malaysia (DOSM) reported that 805,509 individuals with disabilities were registered nationwide, representing approximately 2.4% of the total population. Of this number, 286,634 individuals (35.6%) were identified as having physical disabilities. In light of this significant proportion, this research investigates the experiences and challenges faced by individuals with physical disabilities who use wheelchairs when accessing public heritage sites. The Act establishes the National Council for Persons with Disabilities, ensuring PwD's registration, protection, rehabilitation, development, and overall well-being. Clause 26 emphasizes accessibility to public facilities, amenities, services, and buildings, mandating that these environments conform to Universal Design principles to facilitate access for all. Research by (Ang Kean Hua 2019) indicates that wheelchair users in Kuala Lumpur expressed dissatisfaction with public toilets, transportation, and hotel management. Participants recommended improvements beyond basic accessibility, including better staff training to foster a more inclusive and welcoming environment. NGOs such as the Damai Disabled Person Association Malaysia, established in 1998, further support PwDs by advocating for independence, reintegration into society, and equitable employment opportunities. These organizations also raise awareness among authorities and the public about the necessity for structural, social, and educational reforms for the disabled community (Damai Disabled Person Association Malaysia 2023).

Adaptive Technologies for Wheelchair Accessibility

Virtual Reality (VR) immerses users in a simulated environment, allowing interaction through head-tracking technology, while Augmented Reality (AR) overlays digital images onto real-world surroundings. Both technologies have significantly impacted tourism for individuals with accessibility challenges (GCF Global no date). The global VR industry, valued at USD 25.11 billion in 2023, is projected to reach USD 244.84 billion by 2032, with a CAGR of 28.6% (Fortune Business Insights 2024). VR and AR enhance tourism experiences by providing immersive, memorable interactions, improving social engagement, and enabling access to otherwise restricted environments (Loureiro, Guerreiro & Ali 2020; Bailey, Bryant & Hemsley 2021). Paladini et al. (2019) demonstrated the potential of VR in improving access to fragile or restricted cultural heritage sites.

Using the Myin-pya-gu Temple in Bagan as a case study, VR applications offered engaging and educational experiences, increasing visitor interest and awareness of heritage conservation. Adjustments in contrast, lighting, and interactive features further enhance visual clarity and appreciation of architectural details, emphasizing VR's role in heritage education and preservation. Mobile applications utilizing semantic linked data, such as WEMAP, facilitate accessible travel planning for wheelchair users (Liu et al. 2017). Features include real-time accessibility information, route planning, crowd-sourced facility ratings, audio descriptions, emergency assistance, and visual guidance. Such apps serve as practical tools for enhancing accessibility, allowing PwDs to navigate heritage sites independently and safely. Universal Design (UD) aims to create products, environments, and services usable by people of all ages and abilities without the need for adaptation (Burgstahler 2009). Developed by a multidisciplinary team led by Ronald Mace in 1997, UD is grounded in seven principles: equitable use, flexibility, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and appropriate size and space. UD principles can guide the evaluation of existing designs, inform the development of new environments, and educate designers on inclusive practices (Centre for Excellence in Universal Design no date). Accessible design emphasizes fairness and a deep understanding of diverse user needs, contributing to inclusive societies (Crook 2023). The Persons with Disabilities Act 2008, Clause 26(2), reinforces the requirement that facilities and equipment for PwDs comply with UD principles. Consequently, the study of accessible built environments integrates legal mandates, design theory, and technological solutions to remove barriers and promote equitable access for all individuals (Ikhwan Ali Wazani et al. 2021).

International Practices in Universal Design for Heritage Accessibility

Internationally, several countries have adopted Universal Design (UD) strategies to improve accessibility in heritage contexts while preserving historical authenticity. In Sweden, the Royal Palace in Stockholm provides virtual reality (VR) and 360° virtual tours, enabling visitors with mobility impairments to access otherwise inaccessible areas (Kungliga Slotten, 2023). Such digital interventions demonstrate how technology can complement physical accessibility measures in heritage buildings where structural modifications are constrained. Similarly, the European Union initiated the European Cultural Heritage Online (ECHO) project in 2002, coordinated by the Max Planck Institute for the History of Science, to digitize cultural heritage and provide open-access online platforms (ECHO 2015). Although the project concluded in 2004, it highlighted the potential of digital infrastructure in preserving heritage while improving accessibility for diverse user groups. These international practices provide valuable benchmarks for Malaysia, particularly in heritage cities such as Melaka. Adopting digital

platforms that integrate historical documentation, architectural data, virtual tours, and accessibility information could enhance inclusivity while supporting conservation objectives. Such approaches would enable PwDs to plan visits effectively and reduce reliance on physical access alone. Comparative studies further support the adoption of UD principles. Saito (2006) reported that facility managers in the United States and Japan widely recognize the benefits of Universal Design, implementing them at varying levels. These findings suggest that learning from international best practices can inform the development of more inclusive heritage environments in Malaysia.

Strategies for Integrating Adaptive Technologies into Universal Design (UD)

Accessibility is a fundamental component of inclusive environments, particularly for PwDs. However, the absence of adequate accessibility features remains a significant barrier. (Nuratiqah Aisyah Awang et al. 2024) identified that the limited provision of ramps, elevators, handrails, and accessible sanitary facilities often restricts independent access and increases dependence on assistance. Malaysia's ratification of the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) in 2006 reinforces the obligation to ensure equal access to social, cultural, and tourism activities (Nurul Fadzila Zahari et al. 2023). This commitment is further supported by national policies aligned with the National Policy on Equalization of Opportunities for Persons with Disabilities. Consequently, the integration of adaptive technologies within UD principles should be viewed as both a policy requirement and a social responsibility. Effective implementation requires multi-stakeholder collaboration. Wu et al. (2023) emphasized the involvement of governments, non-governmental organizations, industry stakeholders, professionals, and local communities in tourism planning. Given Malaysia's tourism performance, recording 20.14 million arrivals and RM71.30 billion in receipts in 2023, ensuring accessibility at heritage destinations is critical for sustainable and inclusive tourism development. Furthermore, Alshafeey et al. (2019) argued that greater integration of virtual environments addressing diverse disabilities could enhance accessibility outcomes. Adaptive solutions such as portable ramps, temporary lifting devices, and trained assistance personnel offer practical strategies to improve access in heritage buildings without compromising conservation values. Regular assessments by local authorities are therefore essential to balance accessibility compliance with heritage preservation.

Accessibility Challenges in Public Heritage Buildings in Melaka for PWD

This section presents an overview of the accessibility challenges identified at selected public heritage buildings and sites in Melaka. The information was compiled by the authors from previous research and publicly available secondary

sources, including photographs and visitor feedback, to provide contextual evidence of the physical accessibility conditions reported at these heritage sites. The discussion focuses primarily on barriers affecting persons with physical and mobility impairments, particularly wheelchair users, such as stepped entrances, steep terrain, inaccessible circulation routes, and the absence of alternative means of vertical access. As no independent site observation was undertaken for these locations, the findings presented in this section should be interpreted as secondary evidence of reported accessibility conditions rather than as a direct assessment of their current compliance or accessibility status.

Heritage buildings contribute significantly to the architectural identity of a society, as they embody unique historical and cultural values that are both significant and irreplaceable (Abd Rahim et al., 2026). Previous research has identified significant accessibility limitations at the Baba & Nyonya Heritage Museum, particularly for wheelchair users due to the lack of ramps. As noted by Aurélie (2017), the museum entrance is accessible only via steps, and visitor circulation requires movement between the ground, first, and second floors, all of which are connected solely by steep staircases. Figure 1 shows photos of the entrance and the interior of the museum. The lack of alternative vertical circulation or assistive facilities significantly restricts access for people with mobility impairments.

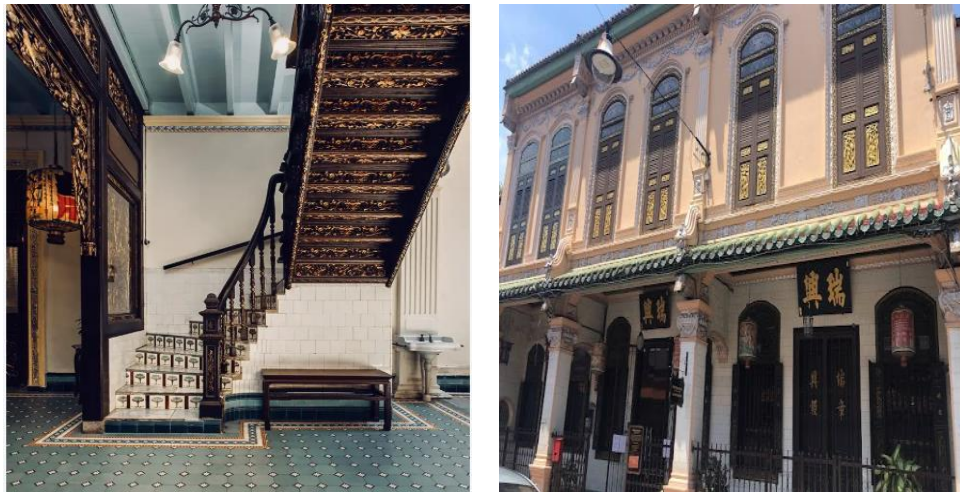


Figure 1: Baba & Nyonya Heritage Museum
Source: Google image, 2026

Saint Paul's Hill is one of the most popular tourist attractions in Melaka; however, it presents significant accessibility challenges for wheelchair users. According to Aurélie (2017), the site is located at the top of a hill, making access

to several historical buildings physically demanding and largely impractical for persons with mobility impairments. The steep terrain and lack of accessible pathways substantially limit independent access for wheelchair users. Figure 2 shows the photos of Saint Paul's Hill.

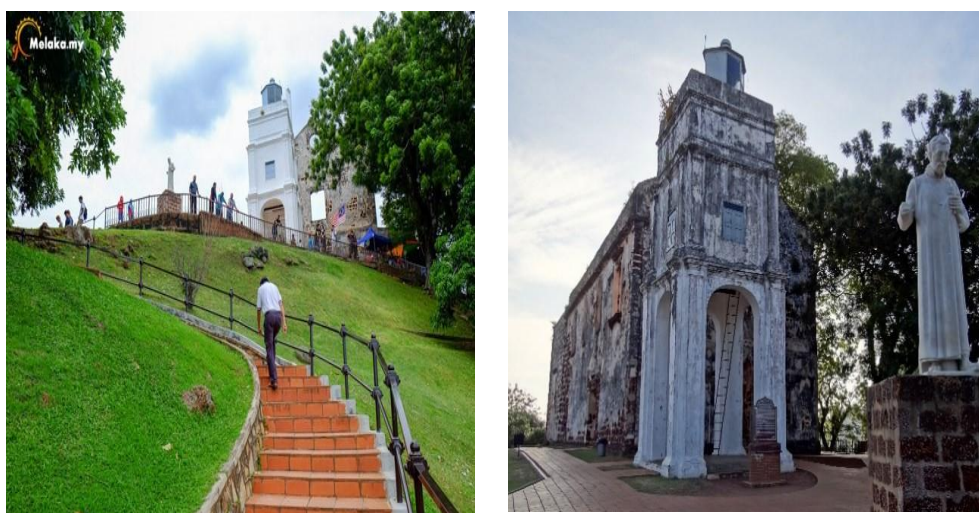


Figure 2: Saint Paul's Hill

Source: Google image, 2026

The design of the Melaka Sultanate Palace Museum was inspired by descriptions of Sultan Mansur Shah's palace in the *Malay Annals*. Constructed between 1984 and 1986 in Melaka City, the museum was developed based on historical annotations found in the ancient *Malay Annals*. Despite its cultural and historical significance, the Melaka Sultanate Palace Museum remains largely inaccessible to PwDs. Visitor feedback reported in Google Reviews indicates that the main entrance is accessible only via steps, which discourages wheelchair users and individuals with mobility impairments from visiting. Figure 3 shows photos of Melaka Sultanate Palace Museum. Furthermore, the absence of designated facilities or ticketing provisions for PwDs suggests limited consideration of inclusive access, contributing to an environment that is not fully welcoming to visitors with disabilities.

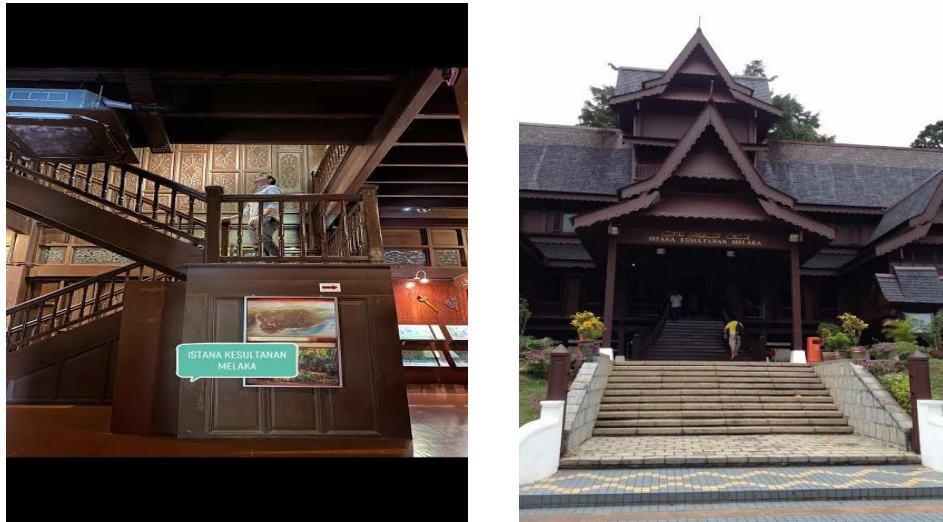


Figure 3: Melaka Sultanate Palace Museum
Source: Google image, 2026

RESEARCH METHODOLOGY

This study adopts a qualitative research approach to explore the accessibility experiences, perceptions, and challenges faced by persons with disabilities (PwDs) in accessing public heritage buildings in Melaka. The study specifically focuses on persons with physical disabilities, particularly those with mobility limitations, as the accessibility issues examined relate primarily to the physical environment, such as entrances, pathways, ramps, stairs, and circulation within heritage buildings. Therefore, the findings should be interpreted within the context of physical disability access and are not intended to represent the experiences of all categories of PwDs.

Qualitative research is well-suited for understanding human behavior and social phenomena within real-life contexts, allowing for the collection of rich, in-depth insights (Ahmad et al. 2019). This approach is particularly appropriate for investigating complex, context-dependent issues such as heritage accessibility, where users lived experiences and perspectives are central to the research objectives. Data was collected through online semi-structured interviews conducted via digital platforms, including Google Meet and WhatsApp, enabling participants to engage remotely. This approach improves flexibility and accessibility, particularly for those with mobility challenges, while reducing logistical and time-related issues associated with in-person interviews. It offers a valid alternative to in-person approaches as it captures both visual and auditory signals, preserves a sense of co-presence, and offers flexibility and convenience for those involved. (Wakelin, et al., 2024). All interviews were conducted with

informed consent, audio-recorded, and transcribed verbatim, providing a comfortable environment that encouraged open and reflective discussions. Interview transcripts were systematically reviewed to identify key statements aligned with the research objectives.

The three heritage sites introduced in the Background section (Baba & Nyonya Heritage Museum, St Paul' s Hill, Melaka Sultanate Palace Museum) were referenced throughout the interviews as examples of accessibility barriers in Melaka's heritage settings. These three were not defined as a set group of case-study sites for all respondents to evaluate. Rather respondents were asked questions about sites they visited in Melaka; the sites they mentioned are listed separately in Table 2. As such, comments relating to access barriers are understood as descriptions of each respondent's perceived visit, and comments relating to adaptive technology or recommendations are understood as their opinions. These interviews do not document the accessibility status of all sites mentioned in the background. Six wheelchair users were interviewed to provide rich descriptions about their personal experiences accessing heritage sites in Melaka. The sample size allows for an exploratory examination of challenges faced by participants; however, conclusions cannot be generalized to all wheelchair users or other types of persons with disabilities. The concept of data saturation was not used operationally in this study. As such, the authors do not suggest that interviewing additional people would not lead to new themes emerging.

Data were manually organized by grouping similar responses, facilitating the identification of common accessibility barriers, user experiences, and suggested improvements. Selected verbatim quotations were included to enhance analytical credibility. This type of content or findings is intended to be illustrative, providing examples that support the theoretical assertions (Eldh, et al., 2020; Thorne 2020). Ethical considerations were rigorously addressed. Participation was voluntary, with participants provided clear information regarding the study's purpose, data usage, and the right to withdraw at any time without penalty. Informed consent was obtained before the interviews, and participant anonymity and confidentiality were maintained by removing identifying information from transcripts and research outputs. All data were securely stored and used solely for academic purposes.

ANALYSIS AND DISCUSSION

Respondents' Profile

Six PwDs in wheelchairs, i.e., four males and two females, have been interviewed via Google Meet. The respondents are 28 to 45 years old. The respondents are expected to answer all questions based on their opinions and experiences visiting

the heritage buildings in Melaka. The profile of the respondents is depicted in Table 1. The respondents were labelled according to the numbers.

Table 1: Details of the respondents

Participant	Designation	Age	Frequency of Visiting Heritage Buildings in Melaka
P1	Male	49	Frequently
P2	Female	37	Rarely
P3	Male	32	Frequently
P4	Female	28	Occasionally
P5	Male	45	Rarely
P6	Male	40	Rarely

Accessibility Barriers in Heritage Buildings

Table 2 summarizes the experiences of PwDs when visiting and accessing heritage buildings in Melaka. Despite Melaka's prominence as a heritage tourism destination, respondents reported persistent physical barriers that limit independent access, including narrow doorways, the absence of ramps and elevators, inaccessible toilets (P1, P3, P4, P6), and uneven floor surfaces that require caregiver assistance, thereby reducing autonomy (P6). In addition, a lack of staff awareness of PwDs needs was identified (P4), indicating that accessibility challenges extend beyond physical infrastructure to include social and operational factors. These findings are consistent with previous studies highlighting that heritage buildings constructed before modern accessibility standards continue to present physical and social barriers for PwDs (Nuratiqah Aisyah Awang et al. 2024; Ruiz-Rodrigo et al. 2024). External access issues, such as uneven surfaces and narrow pathways, further exacerbate these challenges, while inadequate accessibility in supporting facilities, including public toilets and transportation, limits the overall inclusiveness of heritage destinations (Ang Kean Hua 2019; Ikhwan Ali Wazani et al. 2021).

Participants proposed several strategies to improve accessibility, emphasizing the enforcement of accessibility standards to prevent misuse of PwDs facilities (P1, P3), regular inspection and maintenance of lifts (P2), and the proper provision and upkeep of accessible toilets (P3). Design-related recommendations included smooth, bump-free pathways and additional wheelchair-friendly ramps and lifts to enhance independent mobility (P4, P6). Human factors were also highlighted, with calls for staff training to improve awareness and responsiveness to PwDs needs (P4), alongside policy-level support such as free parking for PwDs to reduce access barriers and encourage participation in heritage activities (P5). Collectively, these findings underscore the need for an integrated accessibility approach that combines physical improvements, effective management, staff capacity building, and supportive policies to ensure heritage environments are both preserved and inclusive.

Table 2: Experience difficulties when accessing heritage buildings in Melaka

Experience/ respondents	P1	P2	P3	P4	P5	P6
Facing difficulties	Yes	Yes	Yes	Yes	No	Maybe
Buildings visited	Muzium Kapal	Famosa Area	Stadhuy s & Menara Taming Sari	Menara Taming Sari, Dutch Square & Porta De Santiago	Stadhuy s & Muzium Kapal	Dataran Pahlawan
Barriers faced	Ramps Doorways Toilet	Ramps (old building)	Lack of ramps	Ramps Narrow door Toilet	Ramps Narrow door Toilet	Quite accessibl e
Suggestion for improvement	Local authority and governme nt	Lift	PWD toilet	Smooth pathways Lift Wheelch air friendly	Parking free	Accessibl e pathway

Adaptive technology and Universal Design in Heritage Buildings

Table 3 indicates cautious optimism among participants regarding the use of adaptive technologies to enhance accessibility in heritage buildings in line with Universal Design principles. Most participants (5 of 6; P1, P3–P6) supported the use of Virtual Reality (VR) as an alternative access tool for virtual visitation and historical education, particularly for fragile or physically inaccessible sites. This finding aligns with Paladini et al. (2019), who highlight VR's potential to improve access for PwDs while promoting conservation awareness. However, concerns regarding financial feasibility and long-term government funding were noted (P2). Mobile real-time wheelchair accessibility information applications were also viewed as beneficial for supporting independent navigation, with several participants expressing support (P2, P3, P6), although others raised concerns about data reliability and user adoption (P1, P4, P5). Existing studies demonstrate that crowdsourcing-based systems using semantically linked data can enhance trip planning efficiency and the accuracy of accessibility information (Liu et al. 2017). Participants identified key application features, including real-time navigation, accessibility details, user reviews, emergency functions, and photographic documentation. While most participants expressed willingness to use such applications, hesitation among some users reflects broader challenges related to technological acceptance, particularly among older adults and users who perceive accessibility features as complex or stigmatizing (Kuerbis et al.

2017; Franz et al. 2019). Overall, the findings suggest that adaptive technologies can significantly enhance heritage accessibility, provided they are supported by user-centered design, reliable data systems, and adequate policy and funding support.

Table 3: Adaptive Technology and Universal Design in Heritage Buildings

Theme/Respondent	P1	P2	P3	P4	P5	P6
Virtual Reality	Good alternative	Government fundings	Yes	Yes	Possible	Interesting idea
Mobile real-time wheelchair accessibility information application	Not sure	Yes	Yes	Maybe	No	Yes, great start
Features to be included	Real-time navigation assistance	Real-time navigation, route info, emergency button, user reviews, picture of place.	Yes, Agree to R2.	Information on wheelchair accessible routes	Real-time navigation, user review and location photos.	Yes. All features are important
Willingness to adopt a mobile real-time wheelchair accessibility application.	Yes	Yes	Yes	Maybe – I am old-fashioned	Yes	Yes

Strategies for Integrating Adaptive Technologies into Universal Design

Table 4 highlights the critical role of governance, inclusive design, and capacity building in integrating adaptive technologies within Universal Design (UD) frameworks for heritage buildings. Participants emphasized the need for stronger policy enforcement related to PwDs, regular accessibility inspections, and targeted government funding to support adaptive technologies such as Virtual Reality (VR) and accessible infrastructure, including properly designed ramps (P1, P2, P3, P6). These views align with Wu et al. (2023), who highlight the importance of multi-stakeholder collaboration among government, industry, non-governmental organizations, local communities, and built environment professionals. At the policy level, Malaysia's National Policy on Equalization of Opportunities for Persons with Disabilities provides a foundation for accessibility enforcement, while international studies highlight the shared responsibility of governments, companies, and researchers in developing inclusive virtual and adaptive environments (Alshafeey et al. 2019). Beyond regulation, participants

stressed the importance of inclusive design processes that actively involve PwDs in design oversight and decision-making (P4), consistent with the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD), which affirms the right of PwDs to participate in cultural and tourism activities (Nurul Fadzila Zahari et al. 2023). Training and awareness were also identified as key enablers, with calls for systematic accessibility and UD education for heritage staff and broader public awareness initiatives (P1, P5), supporting previous findings on the role of trained personnel in inclusive environments (Ang Kean Hua 2019). Overall, the findings suggest that integration of adaptive technologies in heritage contexts requires a holistic approach combining policy enforcement, inclusive design participation, staff capacity building, public awareness, and sustained multi-stakeholder collaboration.

Table 5: Strategies and Further Recommendations for Integrating Adaptive Technologies into UD

Theme/Respondent	P1	P2	P3	P4	P5	P6
Government enforcement/relevant authority (rules and policies)	✓	✓	✓	✓		✓
Government funding	✓		✓	✓		
Training to be provided to the museum staff (how to assist PWD)					✓	
PWD community should be included in discussing and overseeing the design features				✓		
Public awareness				✓		✓
Encourage PWD to visit Melaka					✓	
Modify the heritage building – free accessibility, ramps		✓	✓			
Welfare Exco (State Executive Councilor) – address the accessibility issue	✓					

CONCLUSION

This study highlights persistent accessibility challenges faced by PwDs in Melaka's heritage buildings, largely due to physical and social barriers embedded

in structures built before modern accessibility standards. Consistent with existing literature, participants reported narrow doorways, the absence of ramps and elevators, inaccessible toilets, and uneven flooring, which restrict independence and discourage visitation to inaccessible sites. The findings demonstrate strong support for adaptive technologies, particularly Virtual Reality (VR) and mobile real-time accessibility applications, as complementary tools to enhance access, heritage education, and independent navigation. Participants also endorsed the adoption of Universal Design (UD) principles informed by international best practices, emphasizing practical features such as portable ramps, wider doorways, and staff training. While the study is limited by a small sample size, a short study duration, and the absence of prototype testing, it confirms that integrating adaptive technologies with globally informed UD strategies and effective policy enforcement can significantly improve accessibility in heritage contexts. To advance inclusive heritage tourism, the study recommends strengthening accessibility enforcement, funding assistive technologies, involving PwDs in design and decision-making processes, enhancing staff training, and increasing public awareness through targeted education and media initiatives. Collectively, these measures support a holistic approach to creating inclusive, equitable, and socially sustainable heritage environments. This study identifies persistent accessibility challenges faced by PwDs in Melaka's heritage buildings, primarily due to physical and social barriers in structures developed before modern accessibility standards. Participants reported narrow doorways, the lack of ramps and elevators, inaccessible toilets, and uneven flooring, which limit independence and discourage visits to inaccessible heritage sites. The findings demonstrate strong support for the integration of adaptive technologies, particularly Virtual Reality (VR) and mobile real-time accessibility applications, as complementary mechanisms for enhancing accessibility, heritage education, and independent navigation. The findings further suggest that these technologies can contribute to more inclusive heritage experiences by supporting diverse user needs through immersive learning, real-time access to accessibility information, and greater autonomy in navigating heritage environments. Collectively, the findings highlight the potential of adaptive technologies to complement existing accessibility measures and strengthen the inclusivity and usability of heritage sites. Participants also endorsed the adoption of Universal Design (UD) principles informed by international best practices, emphasizing practical features such as portable ramps, wider doorways, and staff training. The study recommends stronger enforcement of accessibility regulations, dedicated funding for assistive technologies, the meaningful participation of PwDs in design and decision-making processes, continuous capacity building for staff, and sustained public awareness initiatives. More specifically, Historical Melaka City Council, Department of National Heritage, museum operators, tourism agencies, and

building owners should strengthen accessibility through regular audits and maintenance, integrate universal design principles into planning and conservation practices, provide appropriate assistive facilities and technologies, enhance staff competency in disability-inclusive services, and establish mechanisms for ongoing consultation with PwDs. These coordinated efforts are essential to ensuring that heritage environments are not only compliant with accessibility requirements but also inclusive, equitable, and sustainable for all visitors.

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