IMMERSIVE INTERACTION USING AUGMENTED REALITY WITH EXPLORATORY LEARNING APPROACH FOR LEMBAH BUJANG HERITAGE

CHOW CHONG BAO

UNIVERSITI TUNKU ABDUL RAHMAN

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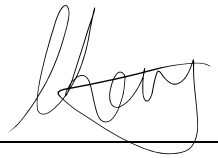
A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Software Engineering with Honours

Lee Kong Chian Faculty of Engineering and Science
Universiti Tunku Abdul Rahman

October 2025

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

Signature : 

Name : Chow Chong Bao

ID No. : 19UEB03928

Date : 11 October 2025

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ACKNOWLEDGEMENT

I would like to thank everyone who had contributed in helping me completing this project. I would like to especially express my gratitude Ts Dr Lee Chen Kang who is my research supervisor for his extraordinary patience and invaluable insights. His guidance has been an invaluable asset throughout the project. Without him, the project will definitely cannot progress smoothly.

Apart from that, I would also like to express my gratitude to my loving parents and friends who aided and support me mentally throughout the project. Their sacrifices on their time to listen to my explanation on project and to be my tester is really invaluable and appreciated.

Lastly, I would like to thank all coding community who had helped to answer my doubt. Their professional skills and knowledge had helped me solve many problems which I encountered during the development.

ABSTRACT

The promotion and preservation of cultural heritage require innovative methods that combine education with interactivity to engage and attract modern audiences. The goal of this project, Immersive Interaction using Augmented Reality with Exploratory Learning Approach for Lembah Bujang Heritage, is to create a web application that uses interactive technologies and augmented reality (AR) to improve users' educational experiences regarding Lembah Bujang's historical significance. A historical corridor that doubles as a virtual museum, an AR module for visualizing ancient reconstructions, an interactive map for site navigation, a mini-game module to gamify learning, and a storytelling module to present captivating stories are the five key modules that make up the system. The development method places a strong emphasis on user-centered design, iterative evaluation, and structured educational objectives by utilizing the ADDIE instructional design model. The project seeks to address the challenges in traditional historical site education, such as difficulty and limited engagement in visualizing historical contexts. This can be solved by offering an exploratory and interactive learning approach. Ultimately, this application aspires to bridge cultural heritage with modern technology, fostering greater accessibility, appreciation, and understanding of Lembah Bujang among diverse audiences, particularly young adults.

Keywords: Augmented Reality, Lembah Bujang, Exploratory Learning, Heritage Perservation, Unity, Vuforia, Blender, 3D Models.

Subject Area: QA76 – Computer Science

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

Augmented Reality (AR) is a new innovative and revolutionary technology development which could be implemented in many industries. Those industries include education industry which requires advancement since its delivery mode is old-fashioned and uneffective. Augmented Reality can help students to better absorb knowledge, provide immersive experiences, and eventually learn better. The use of AR in learning historical sites such as Lembah Bujang promote better engagement, understand history, and at the same time preserve historical sites inheritance.

The objective of this project is to provide an interactive and instructive web-based platform that facilitates users' exploration of historical and cultural heritage locations. The platform aims to make history education more engaging, enjoyable, and available to a larger audience by fusing technologies like Augmented Reality (AR), storytelling, interactive maps, history corridors, and educational mini-games. With this project, we aim to provide a memorable and significant educational experience while improving users' comprehension of historical locations.

1.2 Background

Traditional teaching methods like textbooks, static photos, and lectures are frequently used to teach about historical and cultural heritage places. However, learners may find it difficult to completely comprehend historical settings and recognize cultural relevance if these methods lack involvement, engagement, and effective visualization. With the advancement of technology, modern technologies such as Augmented Reality (AR), interactive storytelling, and web-based platforms offer new opportunities to enhance educational experiences by making learning process more accessible, interactive, and immersive.

With the increased availability of tablets, smartphones, and internet access, integration of digital tools into historical education is now necessary and

feasible. This project endeavours to address the challenges in traditional history learning by developing an interactive web-based application that incorporates dynamic storytelling, AR visualisations, 3D reconstructions, history corridor, interactive maps, and educational mini-games. With these, a more engaging, exploratory learning environment can be created and thus foster curiosity, retention, and understanding of historical knowledge.

1.3 Problem Statement

1.3.1 The current systems have lack of accessibility features

Although all of the systems described provide basic accessibility elements like subtitles, audio narration, and text descriptions, there is a significant difference in the breadth, quality, and effectiveness of these tools between platforms. While some systems have basic accessibility features, they frequently fall short of providing a fully inclusive and user-friendly experience for a varied audience. For example, while 720yun and Lascaux Dailymotion provide subtitles and narration, their implementation is limited, lacking multi-language compatibility, extensive explanations, and increased readability characteristics that might make video more accessible to a global user population. Furthermore, Lascaux Dailymotion limits user engagement by only allowing video-like navigation, prohibiting users from exploring areas at their own leisure. This constraint not only impacts users with disabilities who may need more flexibility when interacting with the content, but it also impedes non-native speakers and those who prefer a participatory experience over passive viewing. According to Seibert (2023), the number of people with disabilities grow higher each year, there are currently 16% of the world's population have a disability. This includes physical, sensory, cognitive, and intellectual disabilities. Hence, it is essential that websites are designed to be inclusive and accessible to all. Similarly, allowing the users to navigate freely and customize their experience aligns. with best practices in UX design, which strengthen the concept of full user control and adaptability to enhance satisfaction (W3C, 2021). So, the question is, how can these platforms strategically enhance their accessibility features to accommodate a wider range of users, ensuring a seamless and engaging experience for all?

1.3.2 Lack of interactive features

Current platforms for historical site visualisation, such as Google Maps and 360Cities, offer minimal 3D and AR elements but lack extensive customisation and interactive capabilities. These constraints impede the development of immersive and instructive experiences, which are critical for engaging users and building a stronger relationship to cultural heritage. According to the Liu (2020), presentation work should keep up with improvements in 'audio-visual techniques, automatic data-processing, communication, and other applicable technologies, and cultural and recreational trends'. It proposes that ‘every media of information must be employed as needed’ during the heritage display process. Furthermore, the interactivity on these platforms is frequently shallow, providing just basic navigation or minimal user involvement. A good innovative feature is appreciated in a project, hence when a good feature is introduced, the feature must be designed well so that it functions well, else it might cause dissatisfaction among the users. For example, in heritage museums that use AR to design their system, the failure of interactive performance to have a large positive impact on the functional value sought by users may explain why interactive features do not have a major positive impact on user happiness (Chen et.al, 2024). The question is, how can these platforms add in and improve interactive features in their system so that it enhances user experiences and at the same time educating the users without making them bored?

1.3.3 Lack of AR functionalities

The existing landscape of virtual heritage platforms lacks comprehensive augmented reality (AR) functions, restricting their ability to provide genuinely immersive and engaging experiences. While many platforms provide rudimentary 3D visualisations or static panoramic views, they do not take advantage of AR technology's full potential to increase user engagement and educational value. This constraint is most noticeable in three critical areas: contextual engagement, real-world integration, and personalised discovery. Firstly, limited contextual engagement. Most AR applications in cultural heritage only display 3D models without allowing meaningful interaction. And according to Yang and Lin (2024) where they use AR on their customer, AR technology creates a realistic product experience that resembles physical

shopping, and therefore it will increase the user satisfaction and engagement. As a result, media usefulness and media enjoyment significantly enhance consumer engagement, leading to stronger purchasing intention. Next, real-world integration. AR could provide real world integration which traditional educational style cannot. Through this integration, it could bring positive effect on engagement and learning. Study shows that students who used AR have been found to have higher level of motivation and engagement, as well as performance on academic tasks. This immersive learning allows students to explore, discover and interact with their environment (Al-Ansi et.al, 2023). Hence proven that AR is beneficial for education since its integration with real world an personalised discovery.

1.4 Objectives

1.4.1 To investigate the potential usage of augmented reality (AR) and digital media technologies to aid in the preservation through digital heritage initiative for Lembah Bujang archaeological site

Augmented reality (AR) and digital media technologies can transform the preservation and presentation of cultural heritage sites such as Lembah Bujang by enabling immersive and interactive experiences. Users can explore historical sites in their original form using AR overlays and 3D reconstructions, obtaining a better understanding of their significance and architectural detail. Through the implementation of AR, this heritage become digital, the site stops aging, its best condition is maintained and captured digitally, allowing the next generation users to behold its original state. Apart from that, augmented reality aids in improving knowledge retention and engagement by providing contextual storytelling and interactive components that normal exhibits lack. Moreover, by implementing AR in digital heritage programs, it can help conserve and document vulnerable archaeological sites from natural disaster and environmental degradation while making them more available to a wider audience, including educators, researchers, and the public. By applying these cutting-edge technologies at Lembah Bujang, we can close the gap between modern innovation and historical preservation, guaranteeing that the site's rich past is cherished and preserved for younger generations to come. As a summary,

AR is appropriate to be implemented in Lembah Bujang as it can preserve this archaeological site, while digital media technologies can help promoting and allowing the users to spectate this archaeological site which is extremely valuable for human history.

1.4.2 To develop an interactive AR aided software for Lembah Bujang heritage through exploratory approach

To develop an interactive AR-aided software for Lembah Bujang heritage, an exploratory approach is needed, which includes testing, investigating, and enhancing a variety of digital techniques to ensure an instructive and entertaining experience for users. This software, can aid the users to be able to virtually interact with historical artifacts, restored temple ruins, and important cultural locations in Lembah Bujang. With the implementation of augmented reality (AR) technology, visitors are able to see how the site looked in the past, participate in storytelling, and expose themselves to the region's historical and cultural significance. The exploratory approach requires evaluating user experience needs, researching the best augmented reality strategies, and iteratively creating an interface that combines digital improvements with actual historical research. Moreover, adding traits such as guided augmented reality tours, and timelines will help make the application more educational and easier to use for a variety of groups, including visitors, historians, students, and researchers. This method not only ensures that the AR software is sound and easy to use, but it also allows ongoing enhancements according to user input and developments in AR technology. Lembah Bujang's historical legacy can be revitalised, preserved, and showed in a way that encourages better involvement and appreciation by creating such interactive AR-aided software, which connects the past and present with contemporary technological advancements.

1.4.3 To evaluate the effectiveness of the AR based software application in supporting the heritage preservation efforts especially to support for archaeological site visualization

To assess the impact of AR-based software on historic preservation, user engagement, instructional value, and site visualisation accuracy are used as standards. By using virtual tours, 3D reconstructions, and interactive

storytelling, AR improves traditional means of presenting and documenting heritages such as Lembah Bujang. This review will look at vital aspect including accessibility improvements, knowledge retention, and the software's involvement in addressing issues like environmental degradation and artifact loss. To evaluate the application's ability to convey cultural relevance and historical narratives, users, archaeologists, historians, and educators will provide feedback via questionnaires and usability testing. Moreover, software stability, usability, and device compatibility will be evaluated to guarantee accessibility for a wide range of audiences. This study attempts to learn AR's capability for revolutionising archaeological site preservation and helping long-term cultural sustainability by fine-tuning the AR-based application based on these insights.

1.5 Project scope

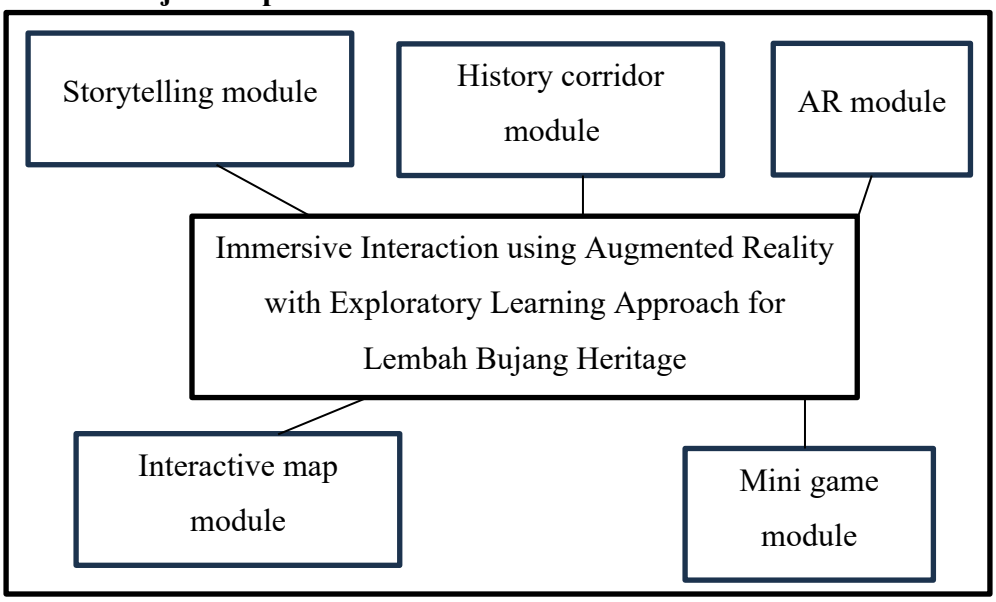


Figure 1.1: Project Scope

1.5.1 Storytelling module

Storytelling module act as the application's narrative backbone, providing users with interesting content about Lembah Bujang's rich past. Storytelling features is created to allow visitors to investigate myths, historical events, and cultural importance using a combination of text, audio, and visual elements. To improve immersion, branching storylines could be considered to be added in which users make decisions that influence the story's development. Furthermore,

incorporating single language audio support can make the module more interactive and interesting while ensuring the quality of work.

1.5.2 AR module

The AR module can superimpose Lembah Bujang's heritage on the physical world through digital content. augmented reality reconstructions of ancient structures, such as towns or temples can be created, so that people can view how these locations looked in their prime. By incorporating minigame module, AR scavenger hunts can be constructed in which users search for virtual artifacts or historical markers strewn throughout the venue. To increase interactivity, AR animations of daily life in old Lembah Bujang, such as traders bargaining or craftsmen at work can also be integrated.

1.5.3 History corridor module

The history corridor module functions as a virtual museum, displaying historical timelines, and cultural insights. 3D models of artifacts that users can zoom, interact, and rotate with could also be added to investigate fine details. We can also include informational overlays which can explain each artifact's usage, origin, and significance. To enhance the experience even more, timeline sliders that allow visitors to see how Lembah Bujang has grown over time also could be included. Video films or audio guides in which archaeologists or historians analyze major finds and their importance is also considered to be included.

1.5.4 Interactive map module

The interactive map module can help users investigate and navigate Lembah Bujang's enormous archaeological site. A dynamic map that highlights major locations of interest, such as temples, excavation sites, and museums could be created. We can also include customisable filters that allow visitors to view specific types of locales (such as religious sites or trading hubs). Different angle of the spot could also be included in order to allow the user to see how to heritage looks like in different angle.

1.5.5 Mini game module

The minigame module can allow learning about Lembah Bujang's history interesting and enjoyable. We can create instructive games that are consistent with the site's past, such as puzzle-solving games in which users repair damaged artifacts or simple RPG like trading simulations in which users barter products like ancient merchants did. Furthermore, quiz games are also developed to test users' knowledge of Lembah Bujang's history, with badges or awards for accurate answers. Scavenger hunts further increase the entertainment and user experience to the website. During AR exploration, we can also create location-based games that require players to visit specific places of the site to obtain material or additional challenges.

1.6 Contribution and significance

1.6.1 Bridging traditional heritage with modern technology

Cultural historical sites often struggle to remain relevance in the digital age, especially when younger generations rely extremely on technology for leisure and education. This work closes that gap by combining contemporary digital technologies into the display and preservation of Lembah Bujang's history. The project uses Augmented Reality (AR), interactive storytelling, and gamification to show how traditional legacy may be remembered using technology while preserving historical purity.

This fusion offers an educational and entertaining exploration of ancient civilisations, giving a new perspective. Instead of being restricted to museum exhibits or books, history is now brought to life through immersive digital experiences. The study highlights the potential of technology-driven heritage experiences, creating a precedent for how historical sites around the world can adapt to remain relevant in an increasingly digital environment.

Moreoever, by including augmented reality reconstructions of ancient sites, the study shows how technology may be used to visualise missing historical landmarks. Users can view virtual recreations of temples, everyday life situations, and trading hubs, making historical narratives more lively and understandable. Furthermore, the use of digital tools promise that historical authenticity is retained while increasing engagement, providing future generations to interact with their past in ways that were previously unknown.

By modernising the presentation of history, this study closes the gap between past and present, ensuring that Lembah Bujang's historical value is not only preserved but also recognised by a new generation of digital-era tourists and learners.

1.6.2 Encouraging exploratory learning

Convention methods of historical education frequently focus on attending lectures or reading textbooks which arepassive learning. However, exploratory learning, in which users actively engage in the process of learning, is significantly more effective at increasing engagement and retention. This study takes a hands-on approach to historical teaching, providing users methods to interact with 3D artifacts, decision-based narrative, and augmented reality simulations and.

Rather than simply reading about history, visitors can see, hear, and interact with history in a meaningful way. AR reconstructions of ancient structures, enable users to see how they appeared in their prime, and interactive timelines and quizzes dynamically test their knowledge. This study prefers active inquiry over passive observation, focusing on learning by problem solving, discovery, and engagement, which can be especially useful for students, researchers, and history buffs.

Furthermore, branching storylines in storytelling modules allow users to make decisions that affect their path through history. This not only enhances users' emotional commitment in the learning process, but it also aids them in understanding the implications of previous decisions. By including AR-based minigames and scavenger hunts, the study switches history instruction into a participatory journey rather than a one-way encounter.

This hands-on approach motivates greater engagement and recall of historical knowledge, guarantees that users actively participate in their learning experience. Finally, by supporting exploratory learning, this study helps to create a more effective and enjoyable educational experience that extends beyond typical classroom training.

1.6.3 Strengthening community engagement and local involvement

One of the most vital components of historical preservation is ensuring that local communities feel linked to their past and take an active role in preserving it. This project focuses community engagement through the use of digital technologies that empower local craftspeople historians, educators, and students to participate in the storytelling and preservation process.

By enabling local voices to contribute to interactive storytelling modules, oral histories, and digital reconstructions, the study allows communities to share their knowledge and opinions of Lembah Bujang's history. This approach closes the gap between lived experiences and historical academia, making sure that legacy is not just studied from a distance, but also enriched by individuals with cultural ties to it.

Furthermore, the initiative promotes educational opportunities by giving digital learning tools to schools and institutions that improve history classes through augmented reality simulations, interactive maps, and gamified experiences. By making history education more interesting and accessible, students gain a better understanding of their cultural roots, which leads to a higher sense of pride and responsibility for heritage conservation.

The project also supports economic prospects for companies and local artists by mixing traditional music, crafts, and performances into digital encounters. This not only remains intangible cultural components, but also encourages visitors to support and interact with local cultural industries, which benefits both the economy and heritage appreciation.

Through the combination of community-driven education, storytelling, and economic opportunities, this project ensures that Lembah Bujang's legacy is not only maintained but actively cherished. It converts historical conservation from a passive preservation model to an participatory and inclusive strategy, ensuring that the coming young generations inherit a past that is actively shared and experienced, rather than simply recalled.

1.7 Target Audience

This project “Immersive Interaction using Augmented Reality with Exploratory Learning Approach for Lembah Bujang Heritage” is developed for young adults whose age range between 18-40 years old. This diverse demography

encompasses university young professionals, students, casual learners, and so on. This age group has characteristics such as familiar with technology, a have a strong inclination toward interactive and immersive digital experiences, and preference for on-demand access to information. These users are in an age where they are eager and curious to explore cultural heritage in a more innovative way rather than traditional passive learning, they are looking for ways that are more educational and engaging. With their fast-paced lifestyles, they require a system that provides intuitive, quick access to important historical information while also allows deep exploration if needed. These needs could be fulfilled by this application because this application incorporate latest AR-based reconstructions that enable the users to interact and visualize historical environments in real time. These reconstructions will empower visual engagement and provide contextual storytelling that enabling the users to fully immerse in key historical moments. This allows the users to have a stronger understanding of the site's cultural importance, also enabling multiple perspectives on the historical events to be built, which is important for current generation's youngsters since ideas and opinion of each person are vital for their growth. Also, given the digital fluency of this age group, the capability of the application for customizing experiences enables the users to adjust their exploration to their interests. Traits such as personalized exploration paths will lead the users through different thematic routes. Gamified challenges will further increase engagement by providing scavenger hunts, interactive quizzes, and puzzle-based tasks which reward users for their knowledge and efforts. This method encourages active learning and promote users to revisit the app for new and evolving content. In a nutshell, the most suitable audience to use this system are young adults due to points mentioned above. This is because this comprehensive approach not only mixes education with entertainment but also promotes cultural appreciation and exploration of the Lembah Bujang heritage. We as youngster should never let these historical sites to fade, we should always learn and pass it to the coming generation in the best condition.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Augmented Reality (AR)

Augmented reality (AR) defines as the the real-time integration of digital content such as images, sound and other data into a users' environment, enhancing their perception of their environment (Hayes and Downie, 2024). AR has two fundamental types, which are marker-based and marker-less. Marker-based is more cost-effective and more accessible, where latter provides a better immersive experience (Hayes and Downie, 2024). One of their key feature is real-time interaction with the environment. AR also require the use of sensors and cameras from smartphones or AR glasses to track and adjust the digital content based on the real-world surroundings so that it can overlay digital content onto physical objects.

2.2 AR issues

While augmented reality (AR) has many promising uses, there are a number of obstacles that could limit its uptake and efficacy. Issues such as data breaches might occur. Ar devices contain different kind of cameras and sensors which are always active. They record, generate, and store new forms of sensitive data which might cause data breaches to happen (Lau & Foo, 2023). Not only that, the absence of design and development for AR apps criteria is also one of the issue. While this technology is still in its infancy stage, standards are not set to maintain the quality of AR applications, each project is unique and hardly compatible with others. This results in harder standard and quality standardization. Even if a standard is set, the acceptance of the standard by all parties come in the last step (Digitalfren, 2024). Hence, for developers, companies, and users to make wise choices while utilizing or interacting with AR technology, it is essential to comprehend these difficulties.

2.2.1 AR benefits

The benefits of using AR is abundant. The possibility for greater interaction is the first advantage of AR that we will examine. AR experiences give people

more immersive and interactive experiences, regardless of whether they are used in eCommerce, entertainment, or even education. Digital content is more interesting when users can engage with it in a real-world setting as opposed to only watching it on a screen. When compared to other marketing channels or technologies, this is possibly one of the biggest advantages of augmented reality.

Another benefit of using AR is enhancing learning by making it more visual and participatory; most users find this kind of learning to be more remembered and interesting. AR has already shown itself to be a powerful tool for igniting creativity and fostering a deeper degree of comprehension. For instance, in a classroom setting, augmented reality (AR) can help teachers demonstrate topics virtually or even develop gamified experiences to supplement conventional teaching strategies and make learning more engaging and memorable. Even while advanced AR software and high-tech headsets are constantly being released, their accessibility is still restricted. Nonetheless, with 6.92 billion users worldwide, cellphones are on the vanguard of gadgets that are available to the vast majority of people (Engine Creative, no date).

Last but not least, AR is being used by museums and historical sites to improve tourists' educational experiences. These organizations may offer engaging and dynamic content that makes history come to life by integrating augmented reality into their tours. The ability to witness historical individuals or events reenacted in their real-world settings enhances visitors' comprehension and engagement with the material. This creative method of teaching enhances the field of cultural and historical education by making learning more interesting and approachable for a wider range of students (DigitalDefynd, no date).

2.2.2 AR limitations

For AR experiences to work reliablely and properly, speedy internet connections are often needed. This dependence may be a major issue, particularly in areas with unreliable or patchy network connectivity. Moreover, buffering and latency caused by high network traffic might affect the immersive experience that augmented reality tries to provide. Developing offline AR capabilities or enhancing network infrastructures worldwide would be vital actions to lessen this.

Apart from that, AR apps are open to bugs and glitches that could disrupt the user immersive experience, just like any other software. These technological pains might be anything from small irritations to serious flaws that obstruct the software's proper operation. To prevent these issues and offer a seamless user experience, a dedication to thorough testing and continuous software maintenance are important (Capsule Light, 2023).

Furthermore, due to AR technology ability to record extensive information about users' surroundings and connects intimately with the physical world, it poses special security and privacy issues. Concerns over illegal access to private information, including location data, visual recordings, and personal identifiers, are raised by this feature. Processing and storing this data could put users at risk for privacy violations if improperly protected. These worries are further heightened by the possibility that AR apps might be used for data mining or surveillance without the express consent of users, which calls for strict user controls and data protection measures (DigitalDefynd, no date).

2.3 Application of AR in various industries

2.3.1 Healthcare industry

In the healthcare industry, AR apps allow users to see detailed, 3D images of every body part as they hover mobile devices over a targeted body part (Hayes, 2025). This levaraging of AR tool has become a great learning tool for medical professionals. Not only that, AR helps practitioners to enhance patient care and results. More accurate and minimally invasive surgeries are now possible due to AR's ability to display 3D representations of a patient's anatomy as the surgery is being performed. AR simulations also help medical students by giving them a safe setting in which to practice surgical methods.

2.3.2 Education industry

AR also aid in education industry. Because augmented reality makes learning more dynamic and interesting, it has the potential to completely transform education. By superimposing digital content on actual pages, augmented reality applications can make textbooks come to life and provide a more immersive and engaging learning environment. This experience subvert the conventional way of education and completely transform the learning process to a fun and

interesting process. In order to improve their memory and comprehension of the subject matter, students can also engage with 3D replicas of historical artifacts or scientific ideas (Engine Creative, no date).

2.3.3 Tourism industry

By providing tourists with an engaging and educational experience, augmented reality has created new opportunities for the travel and tourism sector. Applications for augmented reality (AR) can overlay historical data, user-generated evaluations, and real-time information about tourism attractions onto the user's surroundings. Additionally, AR-powered navigation can improve a visitor's experience by guiding them through new cities (Engine Creative, no date). This completely transform the conventional tourism industry, with the aid of AR, citizens can visit countries from their home.

2.4 AR in area of history

In the area of history, augmented reality (AR) has become an effective tool that is revolutionizing how historical information is accessible, comprehended, and experienced. AR enables users to more immersively view and interact with historical events, sites, and artifacts by superimposing digital information such as 3D models, animations, and interactive content, onto the physical world.

By making distant or abstract historical situations more relevant and tangible, augmented reality (AR) improves the learning process in historical education and heritage protection. Users can virtually explore objects, frequently in their original settings, see reenactments of important events, or experience restored old structures. History becomes more interesting and approachable because to this dynamic approach that helps close the gap between the past and present, especially for younger audiences who are accustomed to modern technologies.

Raghaw, Paulose and Goswami (2018) stated that several studies have described how the latest developments in Augmented Reality can be combined with the possible results of applying new mechanical developments in Augmented Reality. The majority of cited research studies show that Augmented Reality will raise the bar for training when real-world scenarios are implemented in systems. Raghaw himself also started developing education

system in India to leverage this technology advancement to their own good. He use Unity and Vuforia to develop this system. Their system aims to offer students and anybody else who wishes to learn history of India through augmented reality the service of augmented movies supporting the subject. It was created with the goal of supporting the student body in the center, which helps the tutor community make the lessons engaging. They have showed how Augmented Reality breakthroughs can be combined with the possible results of using recent mechanical developments in Augmented Reality.

Through its capability in combining learning with interactivity and exploration, AR plays a crucial role in revitalizing the way history is educated, taught, and preserved.

2.5 Comparisons of similar applications

2.5.1 CyArk

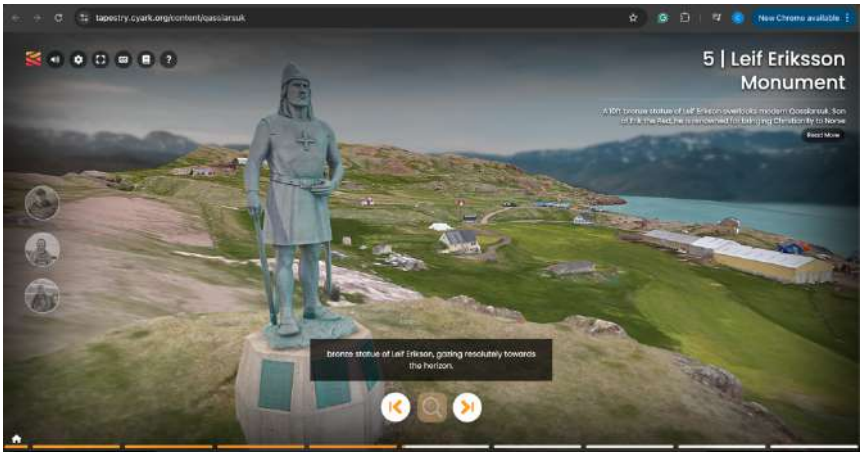


Figure 2.1: CyArk interface

2.5.1.1 Background

Ben Kacyra established the non-profit CyArk in 2003 with the goal of digitally recording, conserving, and disseminating the world's cultural heritage assets (CyArk, no date). The goal of the organization is to guarantee that future generations will continue to be captivated by these important sites.

2.5.1.2 Strength

The ability of this online web application, created by CyArk, to methodically present and highlight each important location inside the assigned territory is one

of its noteworthy features, guaranteeing that users have an organised and educational experience. Users may follow their journey and explore each important destination in a methodical and sequential way thanks to the platform's obvious and easy-to-use progress meter at the bottom of the interface. By using a guided approach, users can navigate the platform without missing any crucial sites. The application also enhances user engagement by providing an interactive experience that allows users easily drag and move about the surrounding locations. Users can more freely to explore the surroundings thanks to this feature, which gives them more immersion and control. To further enhance the experience, an integrated voice-over feature that provides educational explanations about each distinct site is included. By enhancing user comprehension through auditory aid, the virtual tour becomes more approachable and instructive. To address user preferences, the online application also offers a variety of customisation possibilities in addition to previously mentioned functions. Users can switch to full-screen mode for an undistrupted immersive tour, enable or disable sound or voice, change the website's theme for a personalised viewing experience, and toggle captions to help those who might need textual support with a handy button in the top left corner of the interface. The portal also gives the people who want to learn more about the site's cultural and historical significance access to other materials. A tutorial tool is also included to promise a flawless experience, providing detailed instructions on how to utilise the website and take advantage of all of its features.

2.5.1.3 Weakness

The website is panelized by limited navigation, the user thus suffers from both confined opportunity to explore other sites and his own pace. The progress bar at the base of the screen indicate that unlike multicomponent or environmentally oriented platforms, this is a system where you go to class every section of content must be taken in turn. Although a well-organised and thorough tour is ensured by this guided approach, some users may still find it limits their flexibility when interacting with virtual worlds. Instead of letting users choose destinations on their own based on their own interests or curiosities, the website restricts exploration by dictating the order in which locations are presented. Users who want to spend more time at particular sites of interest, return to

particular areas for a deeper look, or skip forward to locations that most interest them might find this restriction annoying. The platform's interactive potential is reduced due to the inability to freely wander, which makes it looks more like a passive experience rather than an interesting, user-driven adventure. Other than that, the absence of autonomous navigation may decrease overall experience and immersion for users who value customised engagement and exploration in virtual spaces. By accommodating a range of tastes and engagement patterns, the addition of an alternate mode that allows the users to follow the guided tour or explore independently will greatly enhance the user experience.

2.5.2 全景故宫

Figure 2.2: 全景故宫 interface

2.5.2.1 Background

"全景故宫" (Panoramic Forbidden City) is a webpage providing users an immersive virtual tour of Beijing's Forbidden City, also known as the Palace Museum. The museum is located inside the Ming and Qing dynasties' former imperial palace, which is known as the biggest and most comprehensive wooden palace complex in the world and was founded in 1925. By using interactive panoramic photos, users may explore the museum's extensive collection of rare artefacts and exquisite architecture. Accessibility to this important cultural heritage site is further improved by enabling tourists to explore the site and take in the Forbidden City's magnificence from different angles.

2.5.2.2 Strength

One of the website’s most noteworthy features is its capability to provide customers a seamless and user-friendly navigation experience, allowing them to navigate the website with ease and flexibility. This website provides a entertaining and smooth method for users to navigate the virtual environment freely, in contrast to certain platforms that enforce rigid navigation restrictions. In order to increase convenience and accessibility, a bottom indicator that functions as a quick-access tool, enabling users to quickly go to important destinations without requiring a lot of manual work is included. In addition to saving consumers time, this function ensures they don't ignore any important highlights in the virtual tour. Moreover, this platform's ability to transition between seasonal settings makes it especially immersive and distinctive, providing a dynamic and visually stunning experience. The website also provides a more in-depth grasp of how the place changes throughout the year by allowing users to explore the landscape in several seasonal variations. Because users may enjoy the scenery in a variety of environmental and atmospheric settings, this feature gives the virtual experience depth and makes it seem more captivating and realistic. Additionally, the platform has many configurable buttons that have been thoughtfully crafted to improve user engagement and customisation. By the customisation of aspects such as navigation preferences, display options, and sound settings, users may customise their watching experience and make it more enjoyable. Other than that, the website included an interactive map that shows the user's current location and directional orientation within the virtual world in order to enhance navigation even better. As users explore, this integrated map is a important tool for directing them and ensuring they always know where they are. This technology effectively provides an captivating and immersive virtual tour experience by merging user-friendly customisations, free navigation, quick-access features, and seasonal adaptability.

2.5.2.3 Weakness

This website's biggest flaw is the absence of an integrated audio explanation, which significantly affects the user experience overall. Even though the platform gives users a visually appealing and interactive method to explore the

website, it is lacking in important historical context or narration to go along with the visual components. Because users are left to deduce the significance of different landmarks and locations on themselves without any contextual guidance, knowledge gap happens due to the lack of guided explanations. Due to this, visitors may find it hard to completely understand the cultural significance and historical of the locations they are looking, although they are allowed to free to move around and enjoy the site's beauty. In the absence of audio narration that offers crucial insights, in-depth descriptions, or historical anecdotes, the platform's potential as an instructional tool is restricted. A stronger uninformative and passive experience could result from users who are not aware with the site's history might felt difficult to understand or relate to the location's deeper importance. Moreover, to improve accessibility for a wider range of users, such as those who learn best by hearing or who might find it challenging to read lengthy text-based descriptions, an audio tour could be developed. Through providing explanations in real-time as visitors using the website, narration might greatly empower the virtual tour's depth and richness and turn it into a more instructive and engaging experience. The platform might bridge this gap by including a well-organised audio component, which would enable users to fully undertstand the environment's cultural and historical significance in addition to engaging with it visually. Users are left with a shallow experience without this functionality, which decrease the website's ability to provide a meaningful and educational virtual tour eventually.

2.5.3 Lascaux Dailymotion

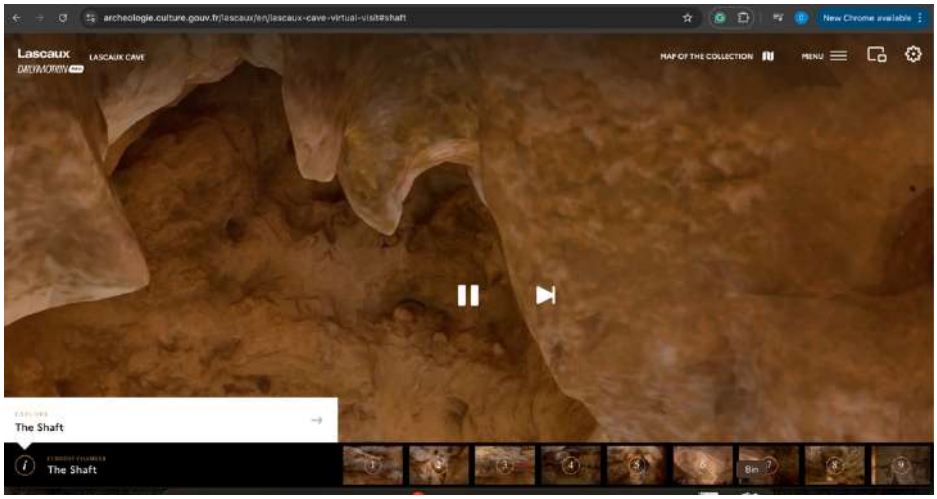


Figure 2.3: Lascaux Dailymotion interface

2.5.3.1 Background

An immersive exploration of the renowned Lascaux Cave is provided by The Lascaux Cave Virtual Visit, celebrated for its exceptional Paleolithic cave paintings. Discovered in 1940, Lascaux has increased and enhanced our understanding of prehistoric art and human origins greatly. Visitors can explore the cave's many areas with the help of this virtual tour, including the Shaft and the Hall of the Bulls, and gain comprehensive knowledge of the artwork and the cave's historical background. Since for conservation reasons, the original cave is closed to the public, the initiative seeks to make this cultural asset available to a worldwide audience.

2.5.3.2 Strength

Thanks to our website's structured and guided navigation experience, the users can explore the cave in an orderly fashion. The platform guides them step-by-step around the cave instead of giving users unrestricted mobility, making sure they stick to a predetermined route that points out significant spots. The navigation bar at the bottom of the interface is a utilised for seamlessly navigating between areas of interest and allows users to go between various portions or chambers of the cave. Then, one of the main components that improves the whole experience is background music. The virtual tour gains an atmospheric element from the engrossing and subdued soundtrack, which

empowers the exploration's engagement and realism. This is because it helps evoke the enigmatic and ancient spirit of the cave environment, this bright improvement makes the user experience more immersive and engaging. Then, the menu button in the upper right corner of the interface also allows access to the website's comprehensive documentation section. This website allows viewers comprehensive details about the cave's discoveries, history, and significance, allowing them to add insightful background information to their visual experience. By studying the material, the users can empower their overall educational experience which provides a more thorough grasp of the cave's cultural and archaeological significance. Moreover, background music not only improves immersion but also makes the trip more captivating by including emotional and atmospheric element into the pictures. A well-rounded virtual tour experience is facilitated by the integration of immersive audio components, educational content, and organised navigation. Although the platform does a good job of presenting the cave's characteristics in a guided fashion, additional interactive features could increase user engagement and provide a more dynamic exploration experience.

2.5.3.3 Weakness

One of its main drawbacks is the restricted amount of exploratory flexibility this platform provides users. In contrast to interactive virtual tours that allow visitors freely move about an environment, this website mostly uses a video-based tour style. Users are unable to move freely throughout the room and are instead limited to following a preset visual pattern because of this. Users who want to explore particular areas of interest at their own leisure or who want to revisit specific portions for a deeper look may find this lack of control over navigation troublesome. A major weakness of this approach is that users must rewatch the entire tour or actively search through the video chronology if they want to revisit a specific location, which can be unpleasant and time-consuming. Compared with platforms that offer interactive controls for fluid movement, this inflexible framework limits the user's capacity to interact intimately with the environment. The overall sense of immersion and engagement is reduced when there is no way to easily select multiple angles, pan about, or zoom in on details. Moreover, another obvious weakness is the lack of guided discussion or illustrative

narration during the tour. Users are left with an inadequate knowledge of the location's historical and cultural value due to the lack of contextual information although the site's visual representation effectively highlights its qualities. Visitors might find it hard to understand the importance of certain sections or artifacts within the site without audio or written explanations. Then, users could enhance their knowledge of the site's history while still having an immersive experience if an educational captions or audio guide were included with the images. Including in-depth explanations would enable visitors to better comprehend the site's historical and archaeological significance and bridge the knowledge gap in addition to appreciating its beautiful qualities.

The platform's instructional and usability value might be greatly increased by resolving these issues by offering contextual explanations and adding interactive exploration capabilities. As it stands, the video tour provides a visually captivating experience, but its potential as a fully educational and immersive virtual tour is restricted by its lack of explanatory help and navigational flexibility.

2.5.4 720yun

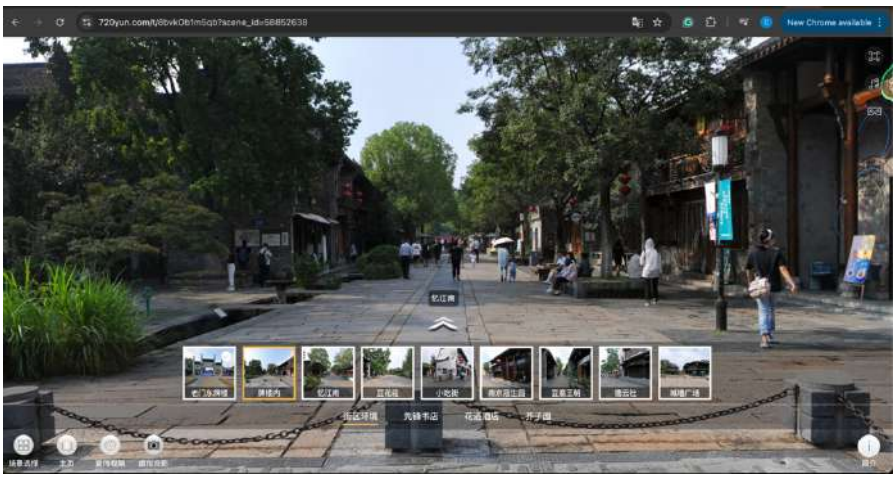


Figure 2.4: 720yun interface

2.5.4.1 Background

720yun is one of the top platforms for creating and sharing 3D VR panoramic material. It provides many services such as 360-degree VR panorama photography, production, mapping, and the distribution of panoramic photos and movies to artists and companies. By offering one-stop solutions for

personalising and displaying content, the platform seeks to increase marketing brand promotion and conversion rates for businesses.

2.5.4.2 Strength

One of this website's main advantages its voice-over feature, which provide thorough descriptions of the history and distinctive features of the landscape. By including insightful background knowledge, this narration enhances the user experience and aids users comprehend the site's historical and cultural significance while they explore. By acting as a virtual guide, the voice-over makes the experience more instructive and immersive by ensuring that visitors learn more than just the scenery's significance and background. Furthermore, another noteworthy advantage is the wide range of freedom this platform provides for navigating the landscape. In contrast to certain virtual tours that force them to follow a set route this website allows visitors to walk freely at the surroundings. It has directional arrows that let users "walk" across the region at their own speed to simulate a real-world exploration experience. By allowing users to control their own navigation and movement while finding sites of interest based on their preferences, this interactive feature greatly increases user engagement. Additionally an easy-to-use indicator at the bottom of the interface that identifies further noteworthy locations to behold in the virtual tour is included. This function helps users in locating important landmarks or areas they might wish to look into more. By providing a structured yet adaptable navigation system, the website simplifies the user experience and keeps users from getting confused or missing important points of interest. This ensures that while saving time, viewers may quickly access the virtual tour's most noteworthy sections.

The website effectively produces an interesting and user-friendly virtual exploration experience by merging educational voice-over narration, a well-structured navigation system, and a great deal of mobility. These elements work together to offer an interactive educational value and experience, making the platform a useful resource for anyone who wish to learn more about the place while taking in an immersive virtual tour.

2.5.4.3 Weakness

One of the system's biggest shortcomings is the lack of background music, which significantly affects the user experience overall. Background music greatly influenced a digital environment's ambiance as it sets the tone, makes the experience more immersive, and improves user engagement. Background music has the ability to immerse their sense of connection to the provided content and engage people in the environment when used correctly. On the other hand, the virtual experience can come across as a little bored without any accompanying music, lacking the emotional value and vitality required to maintain consumers' undivided attention. Moreover, feelings that enhance a digital experience's visual components can be aroused by background music. The platform might give consumers a more emotionally engaging and unified experience by carefully selecting a soundtrack that complements the site's tone and theme. It is known that music helps improve narrative, and including it would strengthen the oervall scenic, historic, or cultural relevance of the area being visited. Since the absence of sound can cause the setting to feel a little empty or detached from reality, the users might find it difficult to completely immerse themselves in the experience without this aural component. Furthermore, background music plays an important role in keeping users engaged and providing the experience a sense of coherence. It provides seamless transitions between various virtual tour portions, reducing consumers from encountering sudden or startling changes when using the platform., Background music can serve as a guiding element with careful planning, gently shifting users' attention and improving their experience as they navigate the digital world. In the end, its full potential is diminished by the absence of backing music, even if the existing system offers useful visual material. In order to solve this problem and provide consumers a more immersive and enjoyable digital experience, a well-thought-out aural backdrop would not only make the platform more engaging and lively but also leave a strong impression.

2.5.5 Google Map

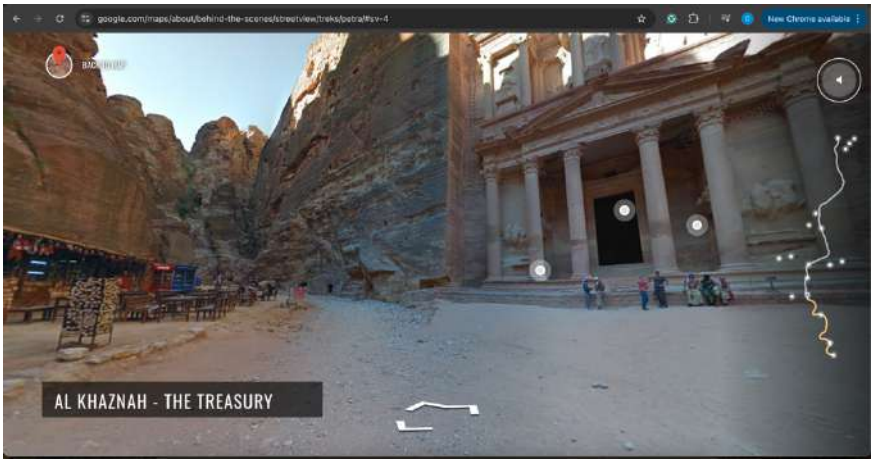


Figure 2.5: Google Map interface

2.5.5.1 Background

Visitors can explore the ancient archaeological site of Petra, Jordan on this website through 360-degree views and panoramic photos. The website is a component of Street View Treks on Google Maps. The website make remote and historically important sites accessible to anybody with internet connection by providing virtual tours of some of the most amazing places on Earth.

As part of the Petra journey, users can traverse the site's renowned rock-cut architecture, such as the Siq (the narrow gorge leading to the city), the Monastery, and the landmark Al-Khazneh (Treasury). Users can examine its buildings, "walk" across the site, and behold its beauty from different perspectives thanks to the trek's interactive design.

People from all over the world will be able to enjoy Petra's breath-taking scenery and rich history thanks to this effort even they do not have chance to visit in person. The main goal of immersive experience is to emphasise Petra's importance as an ancient city and a UNESCO World Heritage site.

2.5.5.2 Strength

One of the websites's most noteworthy features is its wide range of navigational flexibility. This website grants visitors the power to explore the surroundings at their own pace by sliding the screen to alter their view, unlike few other virtual tour platforms that fix a set path or guided sequence. Thanks to this feature, users feel more in charge of their exploration, which offers an interactive and

captivating experience. The whole user experience is enhanced by having freedom of navigation, which makes it more immersive and enables people to focus on their areas of interest. The website also has a voice-over function that informs visitors about the site's cultural and historical value apart from its adaptable navigation. By offering insightful background information and context, this narrative empowers the user's understanding of the area being studied. The software ensures that users not only acquire a greater understanding of its historical significance by incorporating audio explanations but also enjoy the site's visual appeal. This function, which preserving the flexibility of individual inquiry while provides a guided learning experience, is very helpful for those who is not be familiar with the site's history. The platform's presence of a mini-map, is another remarkable quality. This mini-map which act as a navigation tool, enables users to rapidly understand their location in the virtual world. The map offers a user-friendly method of effectively exploring various locations by presenting the user's current orientation and position. The mini-map also has interactive features, such as navigating users to particular areas of the website right away by clicking clickable circles. Without manually navigating the entire environment to get to important sites of interest, this simplified navigation method not only improves convenience but also saves users time.

This platform is highly user-friendly and captivating due to its effective voice-over explanations, mini-map feature, and unlimited navigation. The system at the same time provide the flexibility to explore however they see fit, and they also can take advantage of informative materials and user-friendly navigation. The website offers a engaging and comprehensive digital experience that appeals to both who is looking for in-depth information about the historical site and casual visitors because of the smooth integration of various components.

2.5.5.3 Weakness

One of its main weaknesses is the lack of background music on this website, as it detracts from the overall user experience greatly. In order to set the mood and provide guests a more a interesting nd immersive experience, background music is a must. As a result of its capacity to improve emotional connection, users may feel more immersed in the virtual world. Without it, the website might seem a

little boring or less engaging because there wouldn't be any sound to go along with the visuals. The virtual adventure could feel more emotionally impactful and dynamic with the inclusion of well-chosen background music. Music also can improve users' engagement and memory of content by building a stronger bond between them and the historical or cultural significance of the place being mentioned. Next, another significant flaw in the site is the absence of subtitles, which might cause difficulties for users to learn, especially those who might have trouble following oral explanations. Subtitles are such crucial accessibility element because they allow users to follow along with the narration and ensure that important information is not ignored,. Without it, certain users can find it hard to fully grasp the context of the material being presented due to pronunciation issues, accents, or technical words in the narrative. Moreover, having the selection to read subtitles rather than depending only on the audio explanation would be very beneficial for those who want to browse in a sound-sensitive setting or who have hearing difficulties. By using subtitles, the accessibility would be improved, at the same time enhance user comprehension, ensuring that the cultural and historical details of the site could be fully comprehend by the visitors. This allowing effective engagement of content with the users hence provide a better inclusive experience. Moreover, non-native speakers who read better than listening to a foreign language could find subtitles significantly helpful.

In conclusion, by making the platform more approachable, immersive, and captivating, subtitles and background music would significantly boost the user experience overall. While subtitles would ensure that all users, regardless of their hearing or language skills, could completely understand the content being displayed, background music would contribute to a more emotionally and atmospheric engaging experience. By putting these improvements into practice, virtual exploration would become more approachable, comprehensive, and likely to be utilised.

2.5.6 360cities

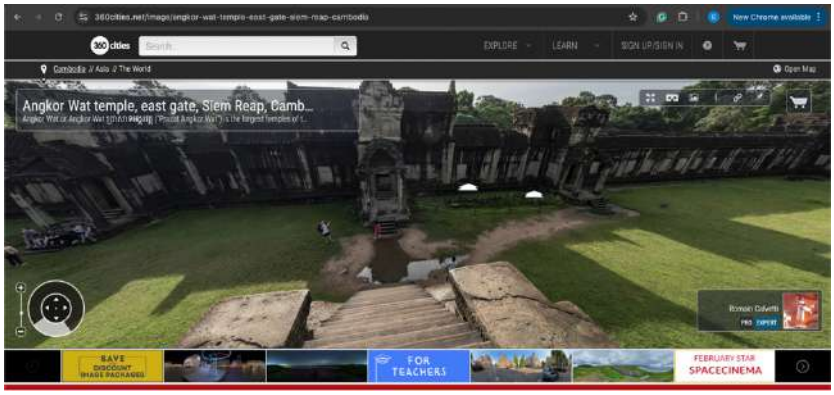


Figure 2.6: 360cities interface

2.5.6.1 Background

The website 360Cities provides users with interactive 360-degree panoramic views of numerous famous sites worldwide, allowing them to virtually tour these areas. We can view this breathtaking panoramic view of Angkor Wat in Siem Reap, Cambodia, which is taken from the East Gate of the temple complex, through the particular website that is linked. Users are able to move around the historic temple of Angkor Wat in real time and rotate the image to see the site from various angles by visiting this page. The image's dynamic features can make visitors think that they are actually standing there, providing a realistic and unreal detailed visual experience. 360Cities enables exploration of the majesty of Angkor Wat's architecture and surrounding landscape, which offers an instructive and immersive approach to see this UNESCO World Heritage site without having to be there physically.

With the help of the platform, users may digitally "travel" to some of the most historically significant and amazing places on earth, granting them access to high-quality, visually rich panoramic photographs that might otherwise be challenging to see in person.

2.5.6.2 Strength

Through allowing users to freely explore their surroundings in a highly interactive way, the website prepares an immersive and dynamic experience that captivates the users. Drag the screen in different direction to move about the virtual environment at their own pace. This enables the visitors to roam around

the room easily. 360-degree navigation's notable element, which simulates the feeling of movement in the real environment and adds a sense of control and presence to the whole experience. This feature ensures that visitors can explore every detail and angle without any limitations, including a historical site, an amazing natural scenery, or a real estate property. The user experience is further empowered by the responsive and fluid interface design, which makes navigation feel more natural. Furthermore, the website's dynamic interface can make exploring easier as well as encourages a closer bond between the user and the virtual world. The platform provides consumers the ability to take charge of their trip, which allows them to interact with the information in a personalised and meaningful way. Virtual tours benefit greatly from this degree of engagement since it turns passive viewing into an interesting and dynamic experience. No matter the customers are appreciating the fine features of a historical landmark or assessing the layout of a house, the smooth navigation ensures that they can focus on the material itself. Essentially, the website's design places a high value on user autonomy and immersion, which makes it an effective tool for entertainment, discovery, and education.

2.5.6.3 Weakness

One of this website's obvious flaws is its arrow navigation system, which lacks relevancy and intuitive design. When a user clicks on the arrow in the current scene, they are often taken to a completely unrelated view, such as from an outdoor to an indoor scene without any logical development or obvious context. The user's exploratory flow may be disturbed by this mismatch, making it challenging to follow a logical path or story. A better strategy would greatly increase usability and ensure a more seamless, predictable navigating experience, such as offering a sneak peek at the upcoming scene or labelling arrows with precise locations. Moreover, by neglecting voice-over narration and background music, the website misses out a chance to improve user engagement. These features are essential for creating an immersive and engaging environment because they can add contextual information, emotional depth, and a more polished presentation. In order to enhance the whole experience and make it more accessible to a larger audience, voice-over narration could provide architectural details, historical context, or guided instructions. Whereas

background music should be used to build the mood for various scenes. With these mentioned functionalities, the site will feel more dynamic and interesting.

2.5.7 Similar applications comparison tables

Table 2.1: Table of features comparison

Feature	Cyark	全景故宫	Lascaux Dailymotion	720yun	Google Map	360cities
Freedom to Navigate		✅		✅	✅	✅
Guided Tour	✅	✅	✅	✅		
Subtitles	✅					
Map for Navigation		✅			✅	
Scene Customization	✅	✅				✅
Quick Jump to Key Locations	✅	✅	✅	✅	✅	

Table 2.2: Table of multimedia elements comparison

Feature		Cyark	全景故宫	Lascaux Dailymotion	720yun	Google Map	360cities
Audio	Background music			✅			
	Narration	✅			✅	✅	

	Sound effect						
Text		✅	✅	✅	✅	✅	✅
Graphics		✅	✅	✅	✅	✅	✅
Video		✅		✅			
Animation	2D						
	3D						
AR							

Table 2.3: Table of non-functional element comparison

Feature	Cyark	全景故宫	Lascaux Dailymotion	720yun	Google Map	360cities
Consistency	High	High	Medium	Medium	High	Medium
Simplicity	Medium	High	Medium	High	High	Medium
User centered design	High	High	Medium	High	High	Medium
Performance	High	High	Medium	Medium	High	Medium
Responsiveness	High	High	Medium	Medium	High	Medium

2.6 Exploratory Learning Approach

2.6.1 Overview

Exploratory learning approach is an approach where it is constructed around the learner while the teacher facilitate the process, inquiry-based, interactive and experience based, and sometime messy and noisy (Canon Exploratory School, no date). It require the students to participant and intereact actively. The students are encouraged to look and explore around in order to arouse their curiosity to

learn. This project utilizes this approach by enabling the users to actively engage with historical content rather than passively consuming it. With the aid of AR reconstructions, interactive storytelling, navigative maps, history corridors, and educational mini games, users are encouraged to discover information at their own pace, make choices, and interact with the learning materials. This self-guided, hands-on experience promotes deeper, broader understanding, personal connection, and critical thinking to the historical and cultural heritage being presented.

2.6.2 Advantage of exploratory learning approach

The exploratory learning approach emphasizes discovery, experimentation, and hands-on engagement rather than direct instruction. This enables the students to focus on the learning process since they are required to explore by themselves. It has been proven by research that exploratory learning can result to increased levels of student motivation, improved critical thinking skills, and better retention of knowledge and information (Pollitt, 2024). National Academy of Sciences had perform a study where they found out that students engaged in inquiry-based learning show and demonstrate a greater gains in skills and knowledge compared with the students in traditional classrooms (Kuhn et al., 2000). Apart from that, exploratory learning has proven that it can promote students' natural curiosity through hands-on activities. Through the activities, the students can also foster self-confidence and independence since they are depending on themselves. This allows the students to develop thinking out of the box mindset which promote creativity (Ducklings Nursery, no date). When traditional approach where spoon feed is normalise is used toward the students, the students experience cognitive fluency, where they process the input or information superficially and they think they understand the information that they actually do not understand(DeCaro *et. al*, 2023). This fake understanding frequently lead to underperform of the students. This could be solved using exploratory learning approach.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Overview

The author adopts a structured instructional design approach to guarantee the development of an effective yet engaging web-based educational platform for this project. The methodology chose should emphasizes user-centered design, modular system development, suitable for educational projects, and exploratory learning principles. The process begins with requirement gathering using surveys, followed by careful planning, design, development, implementation, and testing. Each module mentioned in project scope will be developed following each process strictly. A suitable methodology is crucial for the successfulness of this project.

3.2 Comparison of different methodology for software development

Table 3.1: Methodology comparison. Source: Compiled from various sources including Bates (2014), Jay (no date), Geeksforgeeks (2025), and Kvartalnyi (2024).

Criteria	**Waterfall**	**Agile**	**Spiral**	**ADDIE**
Flexibility	Low	High	High	Medium
Risk Management	Low	Medium	High	Medium
User-Centric Design	Low	High	Medium	Medium
Suitability for Educational Projects	Medium	Medium	Medium	High
Iterative Development	No	Yes	Yes	Yes (through Evaluation)
Complexity to Manage	Low	Medium	High	Low

Emphasis on Evaluation	Low	Medium	High	High

3.3 ADDIE model

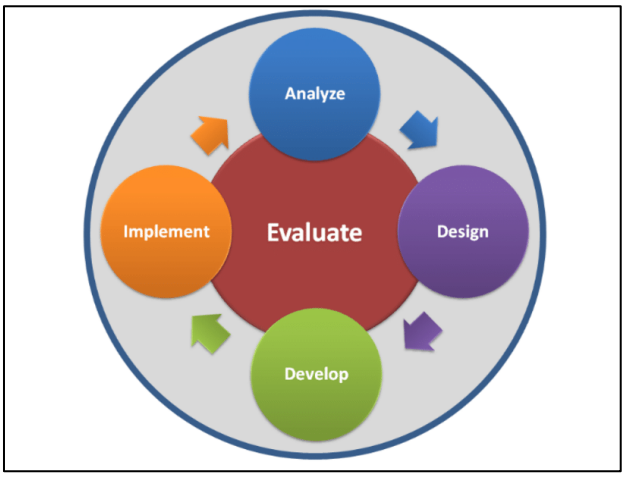


Figure 3.1: ADDIE model (Teh, 2013)

ADDIE model is a learning development model where each character stands for Analysis, Design, Development, Implementation, and Evaluation (ELM, no date). It is a systematic instructional design framework used to enlighten the process of creating training program and education. It serves as a comprehensive roadmap for training developers and instructional designers. This iterative process begins with discussing and analysing the learners' needs, followed by designed the instructional method, developing the content, implementing the solution, and lastly evaluating its effectiveness. The ADDIE model ensures that training programs are effective, efficient, and aligned with organizational and learners' objectives by structuring the creation of learning experience in this way. One of the reasons why we should choose ADDIE model in our development is because helps instructional design to create a structured process. This model provides a direct structure for instructional designers to follow as they develop educational programs, ensuring that all key components of instructional design are considered and addressed. The next purpose ADDIE model serve is aligning the instructional actions with learning outcomes. Beginning with a detailed analysis phase of the ADDIE approach, you may thoroughly align all instructional materials and actions with the learning objectives, increasing the likelihood of these objectives being realised. It also

serves to facilitate data-driven decision-making. The ADDIE methodology promotes fact driven decision making by gathering and analysing data at each level, enabling instructional designers to make informed changes that improve the learning experience (Vulpen, no date).

3.3.1 Importance of ADDIE model

The first importance of using ADDIE model is it can provide structural framework. Throughout the training development process, the ADDIE model provides a methodical, clear outline for instructional designers to follow. It has five stages, they are analysis, design, development, implementation, and evaluation. This systematic approach ensures that each phase is planned and implemented accordingly, decrease the possibility of oversight or inconsistency. Following a specified method prevents instructional designers from going out of scope. They help in staying organised, and manage the challenges of training development in a systematic manner. This clarity is significant when working on large-scale projects or collaborating across different teams, as it ensures that everyone understands the project's main goals and timetables (ELM, no date).

The second importance is flexibility. The ADDIE model is organised and flexible. It is allowed to be tailored to different learning requirements and settings. Instructional designers can tailor each phase based on individual situation, whether it is a hybrid format, classroom-based training, or e-learning. This adaptability makes the model suitable for a wide range of sectors and educational contexts. For instance, the design and delivery of academic instruction may differ greatly from corporate training, but the ADDIE framework may be modified to accommodate both. This adaptability enables instructional designers to cope with changing learner needs and technological improvements while maintaining the teaching process (ELM, no date).

Next, the ADDIE model also provides comprehensive analysis. Its emphasis on doing a thorough analysis at the beginning of the instructional design process is one of the ADDIE model's outstanding features. This step includes assessing learner needs, environmental conditions, and desired learning outcomes. By making time to a in-depth investigation, instructional designers can design training solutions that are not only targeted but also more effective in meeting educational main goals. This technique helps in identifying skill gaps,

audience characteristics, and contextual constraints, making sure that the training is practical and relevant. Comprehensive analysis establishes the groundwork for all subsequent phases, making training development more informed , well-structured, and deliberate (ELM, no date).

Moreover, ADDIE model encourages iterative process. The ADDIE methodology promotes an iterative approach to instructional design, which includes continual revision and review. This cyclical nature ensures that each stage of the process is properly reviewed and improved based on performance data and feedback. For instance, following the deployment phase, evaluation findings might be used to revise delivery methods or training material, increasing the overall success of the program. This dedication to continuous improvement allows instructional designers to handle growing difficulties, building new insights, and keep training materials up to date. As a result, the development of high-quality training programs that adapt to the changing demands of learners and organisations is promised with this iterative process(ELM, no date).

3.3.2 Analysis phase

The instructional problem is defined, the instructional objectives and goals are set, and the learner's existing knowledge and skills, learning environment are identified in analysis phase according to UWB (n.d.). By assessing existing knowledge, skill gaps, and constraints such as time and budget, this phase lays the foundation for the instructional design process. It ensures that there is a clear understanding of the problem and defines measurable outcomes (Gupta, 2025). During analysis phase, there are 6 questions we should ask ourselves, they are what is the primary goal or outcome of this learning program, who is the target audience, and what are their existing knowledge levels, what specific skills or knowledge gaps need to be addressed, what are the organizational goals this training aligns with, are there any constraints (time, budget, technology) that impact the training, and how will success be measured this program (Gupta, 2025).

3.3.2.1 Phase activites

In this phase, the author will be focusing on understanding the project's goals, the target users, and the technological requirements. But firstly, literature review is done before hand to understand the technical gap. Similar applications are compared. Next, problem statement, project objective, project scope, contribution and significance study, target audience is defined. Hardware and software requirement is determined to ensure the development is smooth. Lastly, methodology to be used in this project is determined.

3.3.3 Design phase

The design phase plans out the structure, instructional strategies, and sequence of the project. Learning objectives, assessment approaches, and delivery methods are defined and selected to align with audience needs and goals. This design phase ensures that every component is keep in sync for an engaging and effective learning experience (Gupta, 2025). During this phase, there are 6 questions to ask, what instructional strategies and delivery methods will best achieve the learning goals, what is the structure and sequence of the content, what types of assessments will be used to measure learning outcomes, how will the content cater to different learning styles, what tools and technologies will be used to support the design, and how can you ensure the learning materials are accessible and inclusive (Gupta, 2025).

3.3.3.1 Phase activites

The design phase clearly defines each activity in methodology used. In this project, we use ADDIE model. Each activity in different phases such as analysis, design, development, implementation, and evaluation are clearly defined. Next, system flow diagram is also designed to clearly understand how to user will use the application. Lastly, storyboard is designed as low-fidelity prototype to show each interface of the application.

3.3.4 Develop phase

The development phase is when instructional designers and developers produce and compile the content elements that were blueprinted during the design phase. During this phase, storyboards, content, and graphics are created. If e-learning

is involved, programmers create and integrate technology (UWB, n.d.). There are 6 questions to be asked, they are what resources need to be created or sourced, are there opportunities to incorporate interactivity or hands-on activities, how will us test the developed materials for quality and usability, are the materials engaging and aligned with the learning objectives, how will feedback from stakeholders be incorporated into the development process, and what version control or documentation practices will be followed during development (Gupta, n.d.).

3.3.4.1 Phase activities

The development phase start with the collection of requirements. Survey is used to collect requirements. The responses from the survey are then used to analyse the requirements from users. Then, each phase will undergo code development phase. After the code development phase, unit testing is conducted. If bugs or failures are found, they are fixed immediately.

3.3.5 Implement phase

During the Implementation phase, the training is provided to the learners via the preferred method. Facilitators and learners are provided with the appropriate materials, tools, and technical assistance. This phase ensures a seamless delivery and monitors learner participation and engagement. There are 6 questions to be asked, they are how will the training be delivered (in-person, online, hybrid), what training or support do facilitators or instructors need to deliver the program, how will learners access the materials, and are there technical considerations, what contingency plans are in place for technical or logistical issue, how will you track and manage learner progress during the training, are there communication plans in place to keep stakeholders informed (Gupta, 2025).

3.3.5.1 Phase activites

During the Implementation phase, user manual is prepared. The detailed instructions are provided to ensure the deliverables are clear and concise. Next, training schedule is arranged to ensure sufficient time is allocated and the training is efficient. Training materials are also prepared to ensure smooth progress. Moreover, feedbacks are collected from participants for post mortem

for improvement purpose. Lastly, unit testing and system testing are conducted continuously for best integrity and performance aspect.

3.3.6 Evaluate phase

The Evaluate phase assesses learner outcomes and gathers input from participants and stakeholders to determine the training's efficacy. Formative (ongoing) and summative (final) assessments are used to identify success and opportunities for improvement. This phase's insights inform future training program improvements. There are 6 questions to be asked, they are did the learners achieve the desired outcomes, and how was this measured, what feedback was collected from learners and facilitators about the program, were there any gaps or challenges observed during implementation, how did the program impact organizational goals, what changes or improvements should be made to the program, and how will the long-term success and relevance of the training be monitored.

3.3.6.1 Phase activities

The Evaluation phase includes activities that assess room for improvement. To evaluate, the project use survey and focus group to collect responses and feedbacks. Next, analyse the responses collected for improvement. Unit test and system test are also conducted in this phase since testing should be carried out throughout the project.

3.4 Project planning

3.4.1 Project 1

3.4.1.1 Work breakdown structure (WBS)

Table 3.2: Project 1 work breakdown structure

Level	WBS Name
1.0	Analysis
1.1	Literature review
1.1.1	Identify similar application
1.1.2	Compare and contrast similar application
1.2	Define problem statement
1.3	Define project objective
1.4	Define project scope
1.5	Define contribution and significance study
1.6	Determine target audience
1.7	Define software requirement
1.8	Define hardware requirement
1.9	Determine methodology used

1.9.1	Select ADDIE Model
1.9.2	Identify works in Analysis Phase
1.9.2	Identify works in Design Phase
1.9.3	Identify works in Development Phase
1.9.4	Identify works in Implementation Phase
1.9.5	Identify works in Evaluation Phase
2.0	Design
2.1	Implement methodology selected
2.2	Design system flow diagram
2.3	Design storyboard
2.4	Define requirement
2.4.1	Prepare questionnaire
2.4.2	Analyse responses

3.4.1.2 Gantt chart

Table 3.3: Project 1 Gantt chart

Process	Durations	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
1.0 Analysis	56 days											
1.1 Literature review	21 days											
1.1.1 Identify similar application	14 days											
1.1.2 Compare and contrast similar application	14 days											
1.2 Define problem statement	7 days											
1.3 Define project objective	7 days											
1.4 Define project scope	7 days											
1.5 Define contribution and significance study	14 days											
1.6 Determine target audience	7 days											
1.7 Define software requirement	7 days											
1.8 Define hardware requirement	7 days											
1.9 Determine methodology used	14 days											
1.9.1 Select ADDIE Model	14 days											

1.9.2 Identify works in Analysis Phase	14 days											
1.9.2 Identify works in Design Phase	14 days											
1.9.3 Identify works in Development Phase	14 days											
1.9.4 Identify works in Implementation Phase	14 days											
1.9.5 Identify works in Evaluation Phase	14 days											
2.0 Design	21 days											
2.1 Implement methodology selected	7 days											
2.2 Design system flow diagram	14 days											
2.3 Design storyboard	14 days											
2.4 Define requirement	14 days											
2.4.1 Prepare questionnaire	7 days											
2.4.2 Analyse responses	7 days											

3.4.2 Project 2

3.4.2.1 Work breakdown structure (WBS)

Table 3.4: Project 2 work breakdown structure

Level	WBS Name
3.0	Development
3.1	AR module
3.1.1	Code development
3.1.2	Unit testing
3.2	Storytelling module
3.2.1	Code development
3.2.2	Unit testing
3.3	History corridor module
3.3.1	Code development
3.3.2	Unit testing
3.4	Interactive map module
3.4.1	Code development
3.4.2	Unit testing

3.5	Mini game module
3.5.1	Code development
3.5.2	Unit testing
4.0	Implementation
4.1	Prepare user manual
4.2	Prepare training schedule
4.3	Evaluate training materials
4.4	Collect feedback from participants
5.0	Evaluation
5.1	Identify room for improvement
5.1.1	Collect responses through survey
5.1.2	Collect responses through focus group
5.2	Analyse responses for improvement
5.2.1	System test
5.2.2	Usability test

3.4.2.2 Gantt chart

Table 3.5: Project 2 Gantt chart

Process	Durations	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
3.0 Development	49 days														
3.1 AR module	14 days														
3.1.1 Code development	14 days														
3.1.2 Unit testing	14 days														
3.2 Storytelling module	14 days														
3.2.1 Code development	14 days														
3.2.2 Unit testing	14 days														
3.3 History corridor module	14 days														
3.3.1 Code development	14 days														
3.3.2 Unit testing	14 days														
3.4 Interactive map module	14 days														
3.4.1 Code development	14 days														
3.4.2 Unit testing	14 days														

3.5 Mini game module	14 days														
3.5.1 Code development	14 days														
3.5.2 Unit testing	14 days														
4.0 Implementation	28 days														
4.1 Prepare user manual	7 days														
4.2 Prepare training schedule	7 days														
4.3 Evaluate training materials	7 days														
4.4 Collect feedback from participants	7 days														
5.0 Evaluation	21 days														
5.1 Identify room for improvement	14 days														
5.1.1 Collect responses through survey	7 days														

5.1.2 Collect responses through focus group	7 days														
5.2 Analyse responses for improvement	7 days														
5.2.1 System test	7 days														
5.2.2 Usability test	7 days														

CHAPTER 4

PROJECT SPECIFICATION AND DESIGN

4.1 Overview

This section outlines the overall system requirement gathering process, project specification and design of the development of this web-based historical site educational system with the incorporation of Augmented Reality (AR). The aim is to translate user requirements gathered into functional and non-functional requirements that guide the development.

This chapter presents the system architecture, system flow diagram, and storyboard. Each component is designed to ensure the system is modular, user-friendly, and aligned with the exploratory learning approach which is suitable for the project.

4.2 Requirement gathering

Requirement gathering plays a crucial role in system development process. This phase ensures that the user needs and project objectives are aligned in the final product. For this project, the author adopted a user-centered approach by collecting feeback directly from the target audience through a structured survey. This method allows efficient collection of both quantitative and qualitative data within a short time. The information inquired is critical in identifying user expectations, preferences, and challenges, which are essential in designing an effective and engaging historical learning application.

4.2.1 User requirement gathering

4.2.1.1 Pilot test

A pilot test is used to evaluate the clarity, usability, and effectiveness of a prototype, questionnaire, or learning content before full-scale implementation. It identifies technical issues, areas of confusion, and improvement opportunities based on real user feedback. The author carried out the pilot test April 19 – April 20, 2025. A total of 5 participants joined the pilot test.

Table 4.1: Pilot test result

Name	Time taken	Language	Content
Chow Xin Lin	3:38	ok	Do not understand few words, such as AR and history corridor
Leong Kel Sern	3:27	ok	Do not understand history corridor concept
Ong Li Zheng	3:57	good	Don't know what history corridor is
Yee Wai Kit	3:13	Ok	good
Liew Shan Heng	3:02	Easy to understand	Ok

4.2.1.2 Survey questionnaire

The author created and distributed an online survey aimed at targeted users of the historical learning web application in order to collect user needs. Due to the fact that Google Forms is accessible and user-friendly, it was chosen as the technology for creating and administering the survey. To gather thorough information, the survey had multiple-choice, checkbox, Likert scale, and open-ended items.

The target demographic was given the survey, and responses were gathered over the course of five days, from April 21 to April 25, 2025. The author received 35 full answers in all. Common tendencies, difficulties in learning history, user familiarity with AR technologies, and expectations for each module of the suggested system were all determined by analyzing the data that was gathered. The Appendix A contains the sample survey questions, and the analysis section that follows discusses the main conclusions.

4.2.1.3 Data collection and analysis

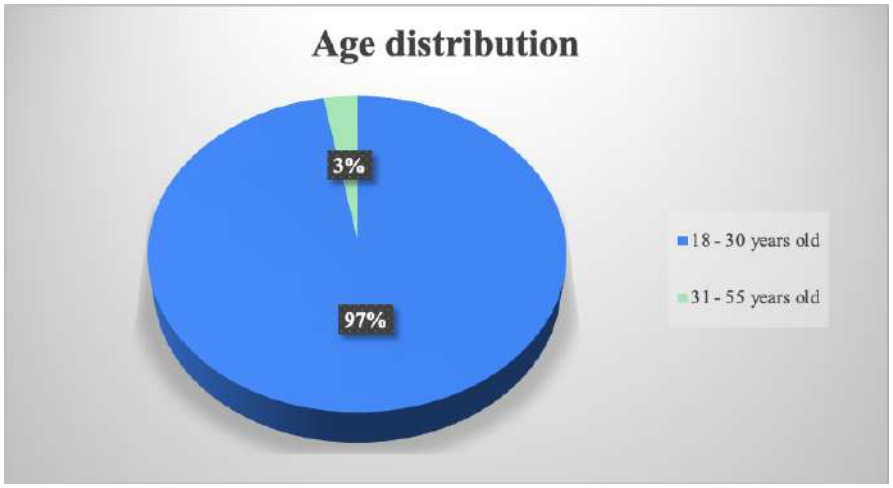


Figure 4.1: Age distribution

Based on Figure 4.1, the age distribution of 35 is mostly between 18 – 30 years old. Among 35 respondents, 34 is between 18 -30 years old. There is only 1 respondent is between 31-55 years old. Most of the respondents is our target audience. This suggests that this survey has certain level of persuasiveness.

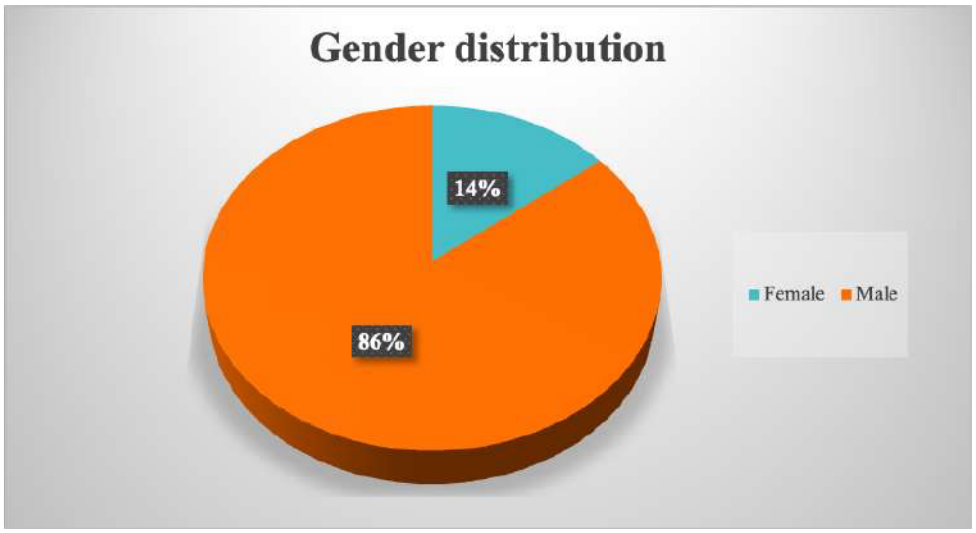


Figure 4.2: Gender distribution

Based on Figure 4.2, 30 of them are male where 5 of them are female. This suggests the sample population has significant gender imbalance. Further study is recommended for greater representation of viewpoint.

Figure 4.3: Occupation distribution

As refer to Figure 4.3, 60% which is 21 of them is student, 34% which is 12 of them is working professionals. 1 of them is sales representative and 1 of them is government employee. This suggests that multiple layer of society is interested in using AR delivery style of learning historical sites.

Figure 4.4: Number of individual visited historical site

As refer to Figure 4.4, 86% which is 30 of them visited a historical site before. Only 5 of them never visited a historical site before. This suggests that historical sites are still relevant to today's generation. The significance of educating society about historical sites is not neglected.

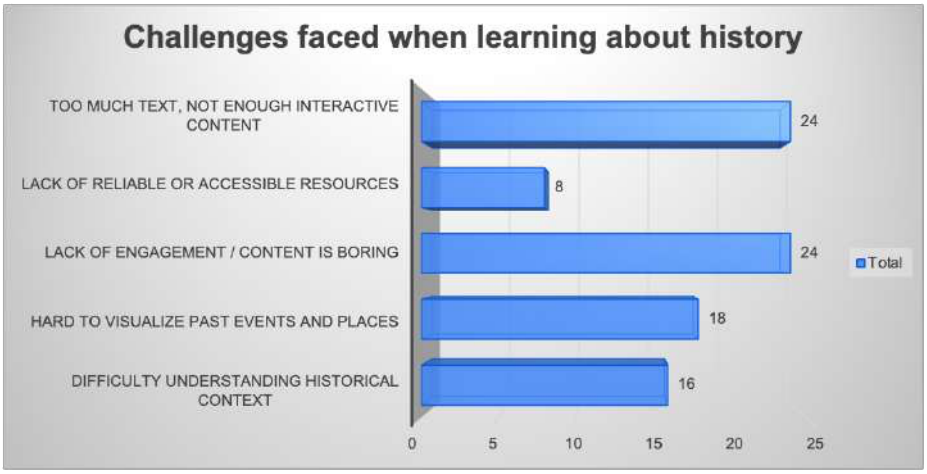


Figure 4.5: Challenges faced when learning about history

As refer to Figure 4.5, 24 of them think that too much text, not enough interactive content and lack of engagement or content is boring is the main challenges faced when learning about history, where only 8 of them think that lack of reliable or accessible resources is main challenge faced when learning about history. This suggest that traditional teaching method is outdated and it cannot attract the interest of the youngsters to proactively seek knowledge about history due to these reasons.

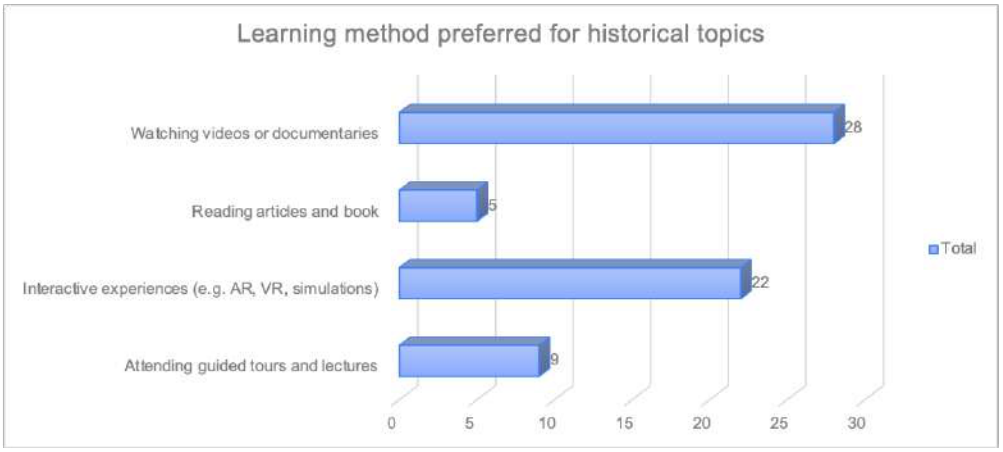


Figure 4.6: Learning method preferred for history topics

As refer to 4.6, 28 out of 35 thinks that the best learning method for historical topics is watching videos or documentation, where 22 out of 35 think interactive experiences is the best learning method for historical topics. This might be due to the fact that AR and VR are not popular and are not well developed yet in this

generation. The current best interactive tool is watching videos and documentation. Hence, the current respondents conservatively choose watching videos or documentation instead of interactive experiences.

Figure 4.7: Effectiveness of traditional learning method

As refer to Figure 4.7, we can clearly see the preference of current generation towards traditional learning method. The most opinion, 'not very effective' is chose by 11 respondents, make up to 31%. Second largest opinion is neutral, 10 of the respondents think that current way of learning method is neither effective nor not effective. This had proven that the traditional learning method is outdated, a new innovative way of delivering knowledge should be invented.

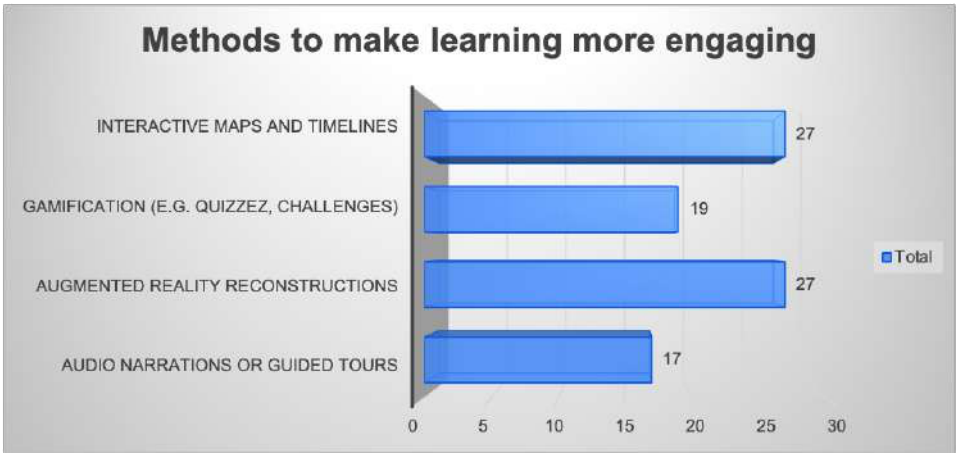


Figure 4.8: Methods to make learning more engaging

As refer to Figure 4.8, 27 out of 35 thinks that interactive maps and timelines and augmented reality reconstructions are good methods to make learning historical contents more engaging. This proven that current generation thinks that interactive way of learning is a better way of learning compared with traditional non-interactive delivery method.

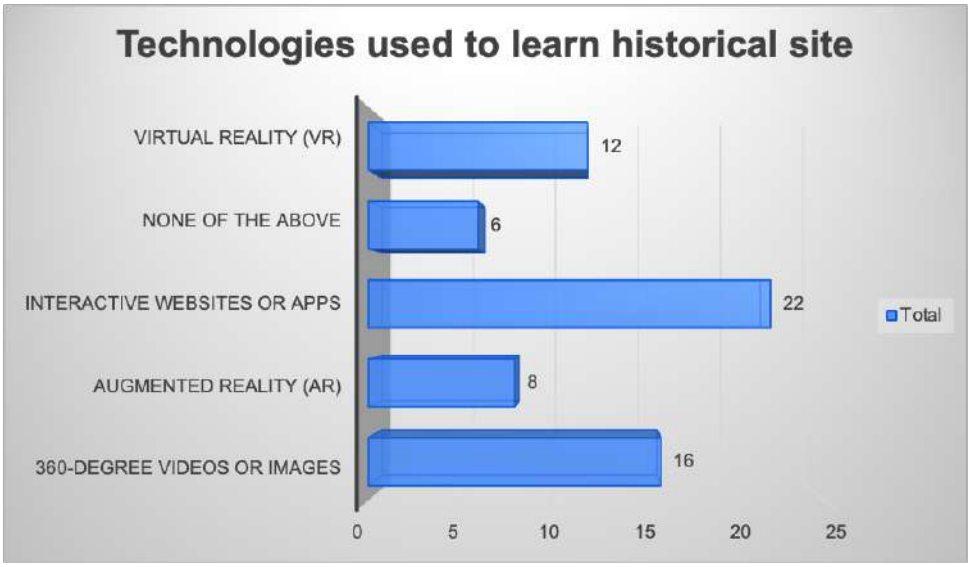


Figure 4.9: Technologies used to learn historical site

As refer to Figure 4.9, 22 of them use interactive websites or apps to learn historical site. Next, 16 of them use 360-degree videos or images. 12 and 8 of them use VR and AR to learn historical site. Since AR and VR are not popular among the society, this phenomenon is normal to be seen. Nevertheless, we can see respondents prefer interactive websites or apps since it provide more indulgence in learning experiences.

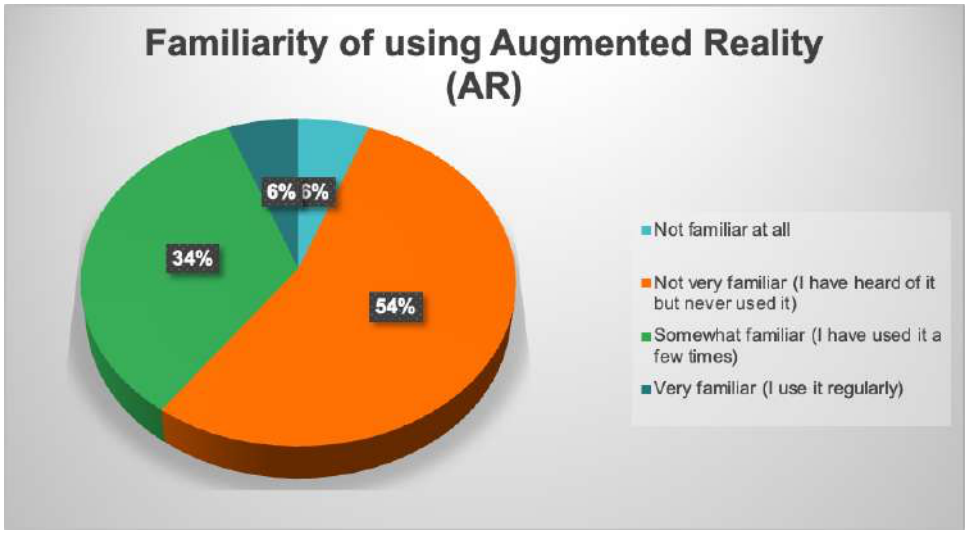


Figure 4.10: Familiarity of using Augmented Reality (AR)

As refer to Figure 4.10, over half of all respondents can be seen are not familiar with AR technology. This is normal since AR is not widely used in current generation. However, there are 34% of the respondents used AR before, this indicates that the generation constantly explores new technology which is a good indication for improvement of society.

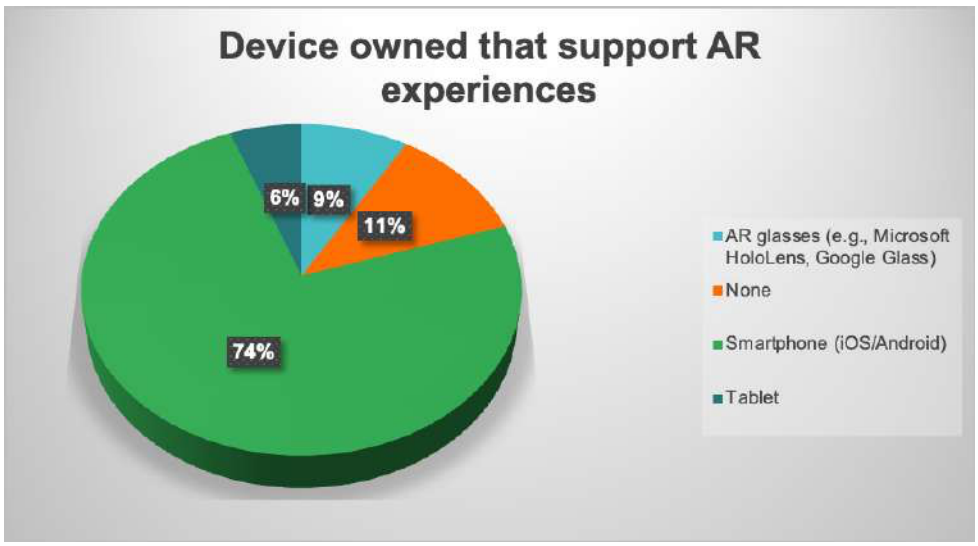


Figure 4.11: Device owned that support AR experiences

As refer to Figure 4.11, 26 of them owned smartphone which can support AR experiences. Only 2 and 4 respondents have none and owning tablet to support AR experiences. In this era, most people has at least smartphone, this allow AR

technology to be supported by these smartphone, hence allowing them to access to AR learning method.

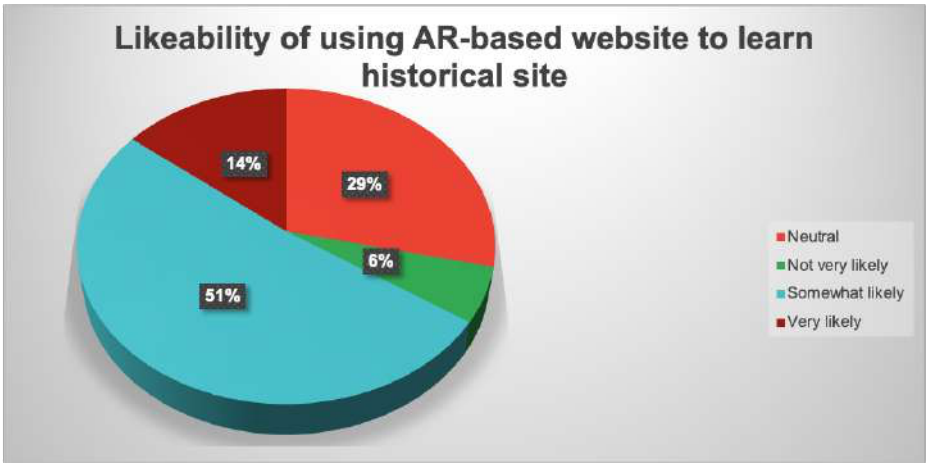


Figure 4.12: Likeability of using AR-based website to learn historical site

As refer to Figure 4.12, 51%, which is 18 of them show that they prefer AR-based website to learn historical site. This shown the eagerness of youngster of exploring new technology. While second largest portion takes up to 29%, which is 10 of them show neutral toward this technology. This indicate the current AR technology has not enough convincing application which can persuade the society that it is a good technology.

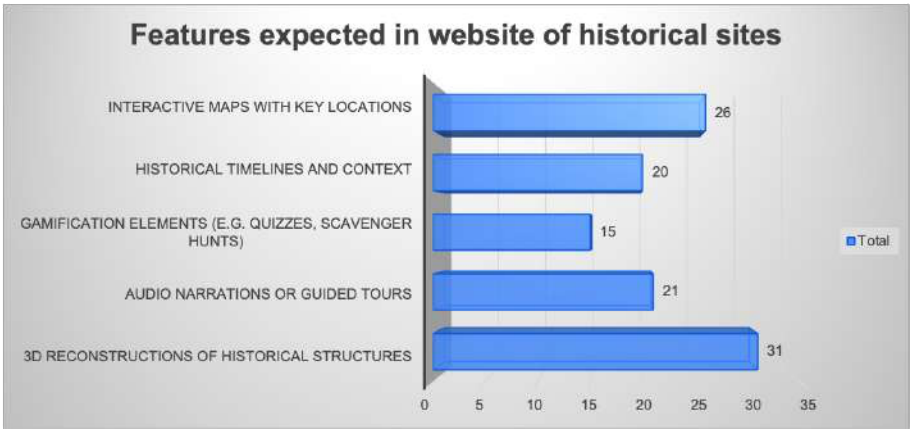


Figure 4.13: Features expected in website of historical sites

As refer to Figure 4.13, 31 out of 35 thinks that 3D reconstructions of historical structures are expected in website of historical sites. 26 out of 35 thinks that interactive maps with key locations helps in learning a historical site. This

suggests that immersive and interactive experiences is important in constructing a successful historical site educational website. The preference over gamification is less probably due to they think education should focus on education not on gamification.

Figure 4.14: Engaging ability of storytelling help in learning

As refer to Figure 4.14, 60% of them think that storytelling somewhat increase engagement in learning. And 34% of them think that storytelling increase a lot in engagement in learning. None choose not engaging or not very engaging. This suggests that current generation prefer storytelling mode of delivering content rather than telling facts like traditional method because it bring a better immersive experiences.

Figure 4.15: Storytelling aid in learning process

As refer to Figure 4.15, only 1 person disagrees that storytelling does not aid in learning process. While 34 other respondents agree that storytelling efficiently help in learning process. This suggests that storytelling is a preferred way of receiving knowledge compared with traditional method since it provide a more interactive way of learning.

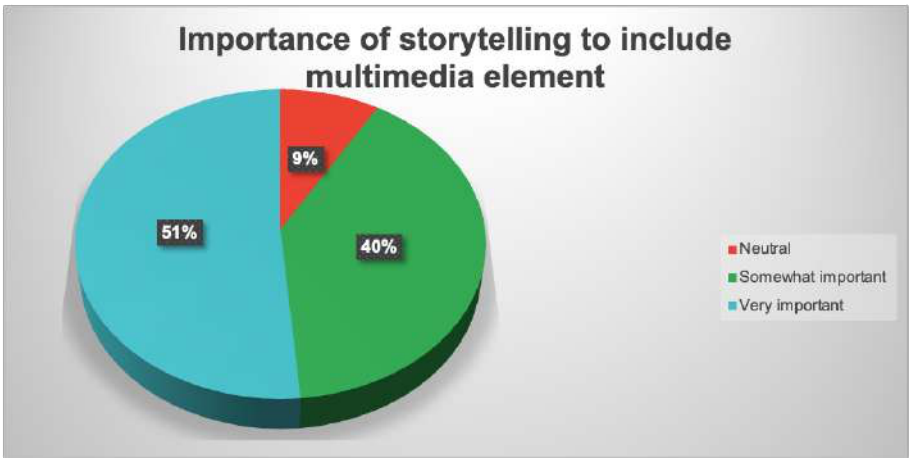


Figure 4.16: Importance of storytelling to include multimedia element

As refer to Figure 4.16, 91% of total respondents agree that it is important to include multimedia element in storytelling. 9% of respondents have neutral opinion on this. None thinks that it is not important. This suggests that people think that multimedia element aid in storytelling to increase curiosity and eagerness to hear the story.

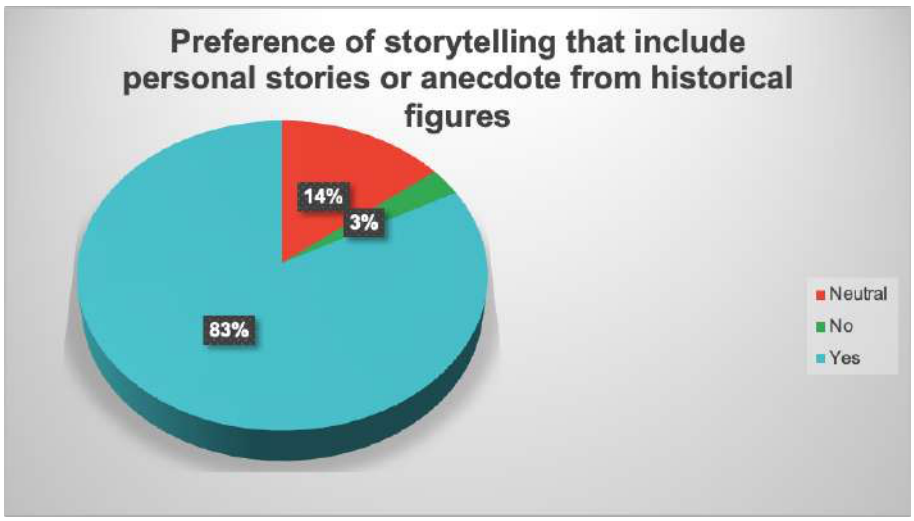


Figure 4.17: Preference of storytelling that include personal stories or anecdote from historical figures

As refer to Figure 4.17, 83% which is 29 out of 35 respondents prefer to include personal stories or anecdote from historical figures. This suggests that people love to hear story of others, compared with rigid facts of history. By provoking their interest, a knowledge can better delivered to the audience.

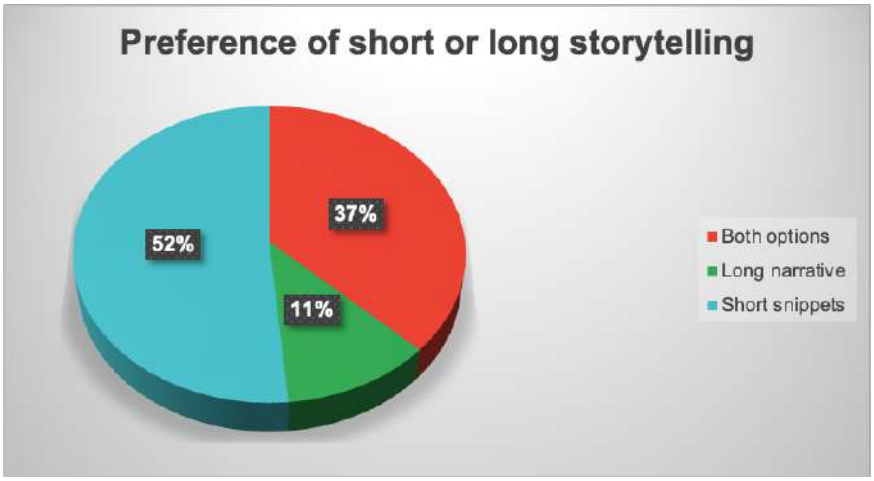


Figure 4.18: Preference of short or long storytelling

Today's trend is short video, same goes to this application. As refer to Figure 4.18, it is proven by this question where 52% of total respondents prefer short storytelling compared with long storytelling. Only 11% of total respondents prefer long detailed storytelling, 37% prefer both options so that they can toggle short or long. Nevertheless, current generation still prefer short concise story rather than long detailed story. This suggests that people are becoming impatience and they seek short and concise story.

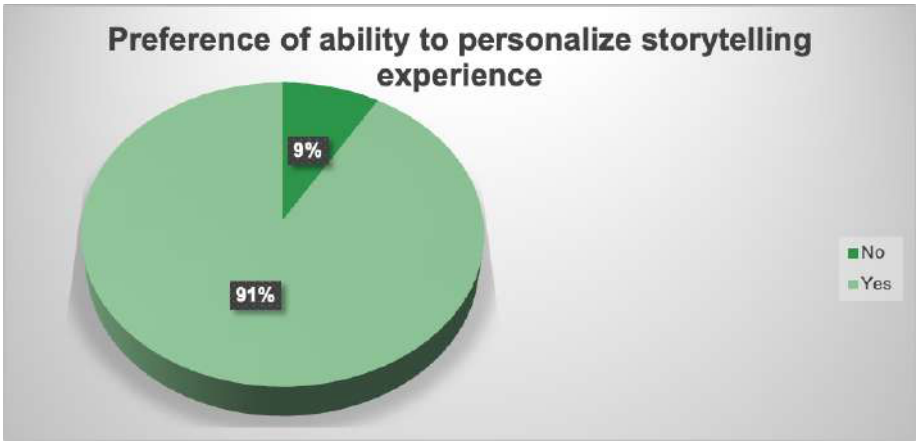


Figure 4.19: Preference of ability to personalize storytelling experience

As refer to Figure 4.19, 91% of total respondents prefer to have the ability to personalize storytelling experience. This suggests that personalization is highly valued to provide an immersive experience of learning. User can choose which voice line, speed and tone they prefer, hence providing best learning experience.

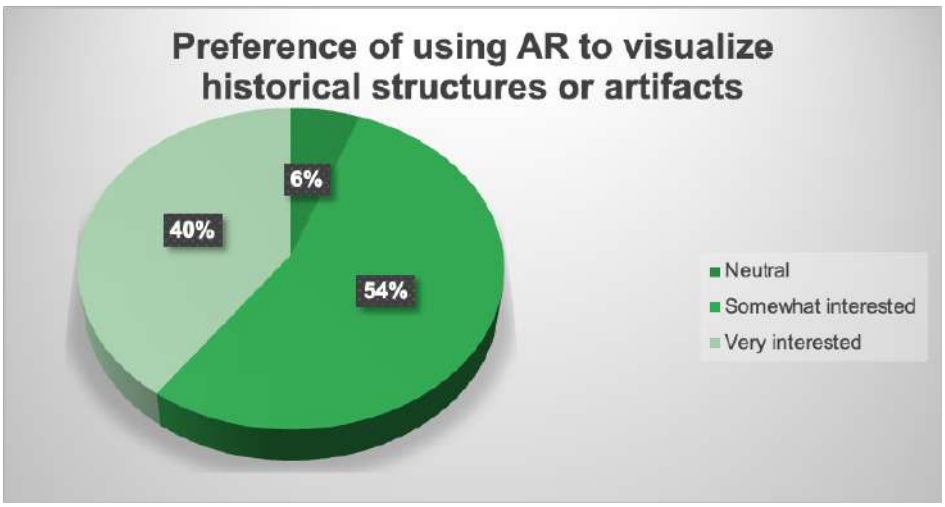


Figure 4.20: Preference of using AR to visualize historical structures or artifacts

As refer to Figure 4.20, 54% of total respondents show somewhat interested in using AR to visualize historical structures or artifacts. While 40% of total respondents is very interested in using AR technology to visualize historical structures or artifacts. None choose not interested. This suggests that the people are very open to new innovative way of learning. People are showing interest in

using new technology such as AR to learn because they are tired of old traditional yet inefficient way of learning method.

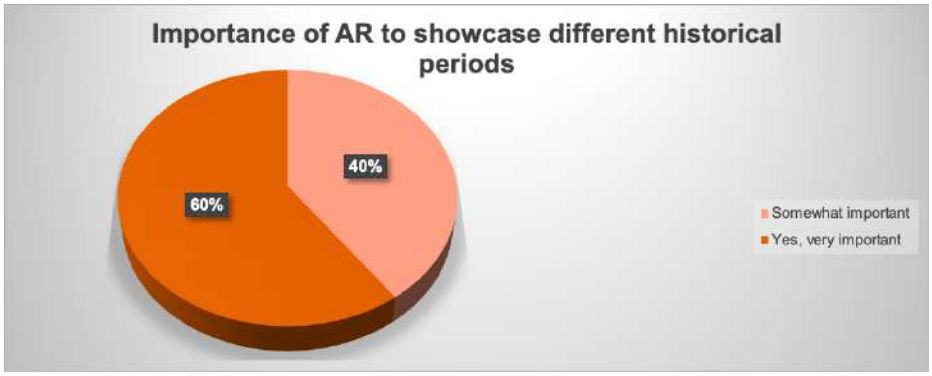


Figure 4.21: Importance of AR to showcase different historical periods

As refer to Figure 4.21, when it comes to importance of AR to showcase different historical periods, everyone agrees that it is important. None choose neutral or disagree the importance of this matter. This is probably everyone is curious of how time has corrupted the historical site. Comparison between ancient and nowadays is important in order to understand, learn, and strengthen the impression. This is to ensure the learning is effective.

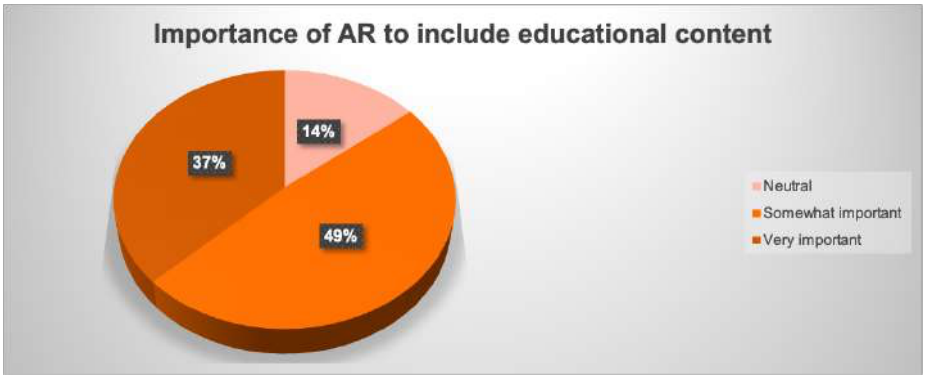


Figure 4.22: Importance of AR to include educational content

As refer to Figure 4.22, 37% of total respondents think that it is very important to include AR in educational content, 49% of total respondents think it is somewhat important to do so, 14% have neutral opinion on this. None thinks that it is not important to include educational content in AR. This suggests that the people think that AR is a powerful tool in education, hence they think that

AR should include educational content. Apart from that, AR ability to adapt in many situation also make it a good candidate in aiding education to achieve new height.

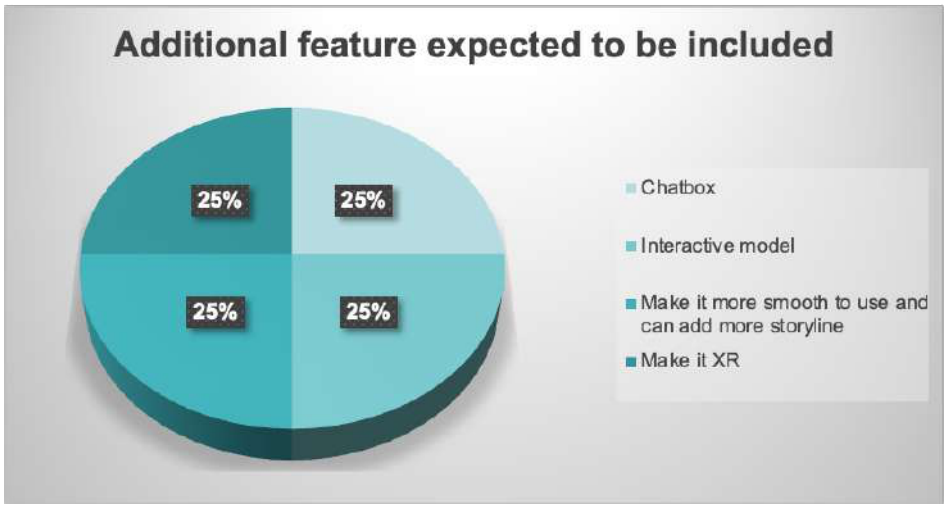


Figure 4.23: Additional feature expected to be included

As refer to Figure 4.23, 4 of them responded to this optional question. When asked what additional feature is expected to be included, respondents stated that they expect chatbot, interactive model, make it smoother to use and can add more storyline, and make it extended reality. These features are important and creative features that can be added into the system. From these, we can see that people always seek for an immersive experience during learning.

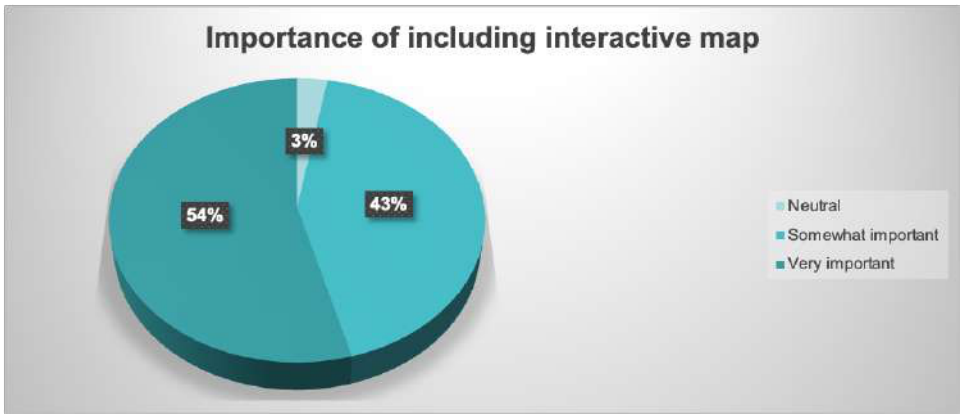


Figure 4.24: Importnace of including interactive map

As refer to Figure 4.24, 54% think that it is important to include interactive map. 43% think that it is somewhat important to include interactive map, 3% has neutral opinion, none think that it is not important. This suggests that interactive map which could navigate the user is very important to user. This could encourage the user to explore more and immerse into the system.

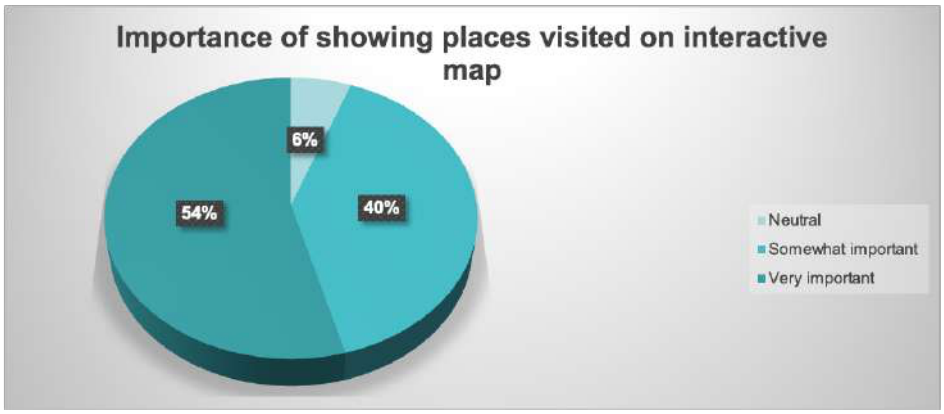


Figure 4.25: Importance of showing places visited on interactive map

As refer to Figure 4.25, 94% of total respondents think that it is important to show places visited on interactive map. 6% has neutral opinion on this, whereas no one think that it is not important to show places visited on interactive map. This suggest that user prefer system that show places visited, this can prevent user from keep visiting the same places. This also can ensure user fully explore the historical site. From this question, we can know that user are eager to fully explore the historical site since they prefer feature that mark places visited so that they will not visit the same place over and over again but fully explore the site.

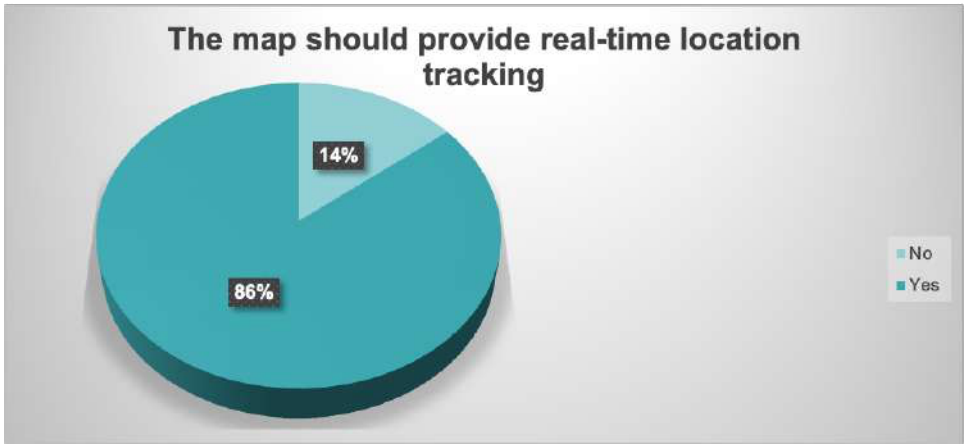


Figure 4.26: The map should provide real-time location tracking

As refer to Figure 4.26, 86% of total respondents agree that real-time location tracking feature should be provided in the map. This suggests that users prefer real-time location which help in identifying their current location. This also prevents them from getting lost in the system. Navigation in each kind of system is always a good design. This increases their confidence in using the system. Hence, we can see respondents are preferring real-time location tracking.

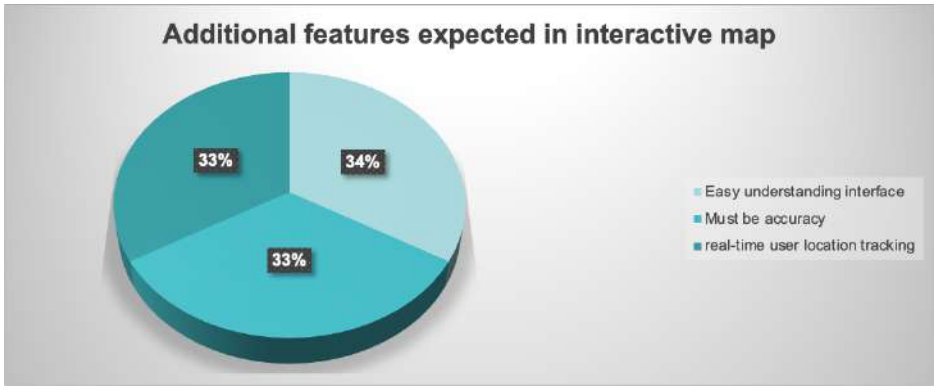


Figure 4.27: Additional features expected in interactive map

As refer to Figure 4.27, 3 respondents suggest that easy understanding interface, high accuracy and real-time user location tracking should be added as additional features in interactive map. We can see the current generation users require clean and understandable interface to ensure smooth experiences. Accuracy is also important so that the educational content delivered is correct and concise. Real-time user location tracking is also mandated so that user will not be lost in the system.

Figure 4.28: Importance of website to include history corridor

As refer to Figure 4.28, 89% of total respondents think that it is important to include history corridor. 11% of total respondents have neutral opinion on this, none thinks that it is not important. This suggests that respondents prefer system with history corridor because it clearly show how a historical site and artifact evolve throughout the time. This could enable users to compare and contrast each artifact and cherish our ancestors for their work.

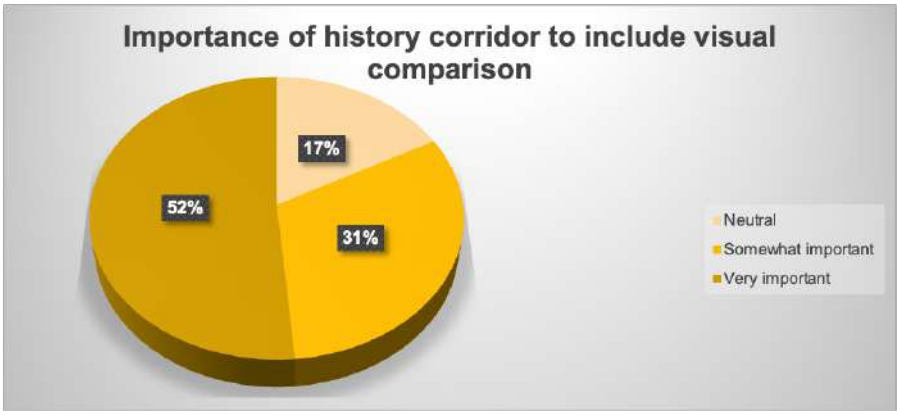


Figure 4.29: Importance of history corridor to include visual comparison

As refer to Figure 4.29, 83% of total respondents think that it is important for history corridor to include visual comparison. 17% of total respondents have neutral opinion on this, none thinks that it is not important for history corridor to include visual comparison. This suggests that users value the difference between past and present. This is because through comparing past and present,

they can understand how corrosion and corruption occur throughout the evolution of time.

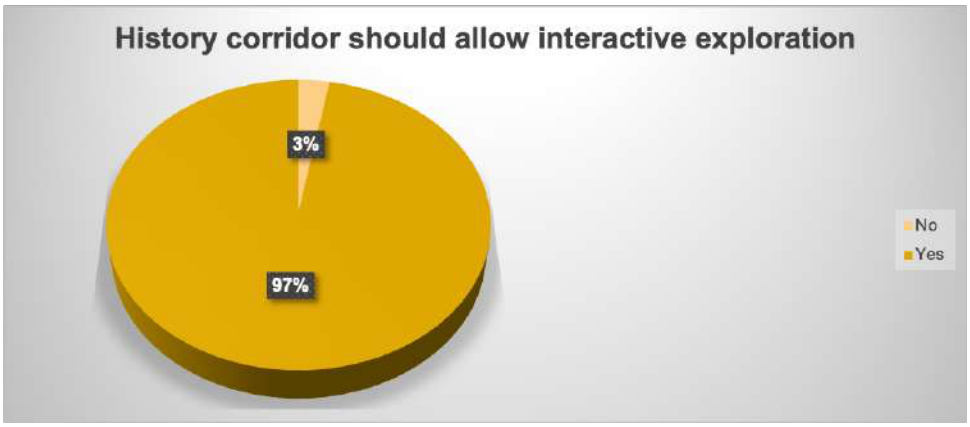


Figure 4.30: History corridor should allow interactive exploration

As refer to Figure 4.30, 97% of total respondents agree that history corridor should allow interactive exploration, only 3% of total respondents disagree that history corridor should not allow interactive exploration. This suggests that respondents prefer an interactive history corridor rather than a factual showing history corridor. One of disadvantages of traditional history corridor is not interactive to users. While designing the history corridor, the author could add in many interactive elements such as 3D model of artifact to increase interactive ability so that users can immerse into the history corridor.

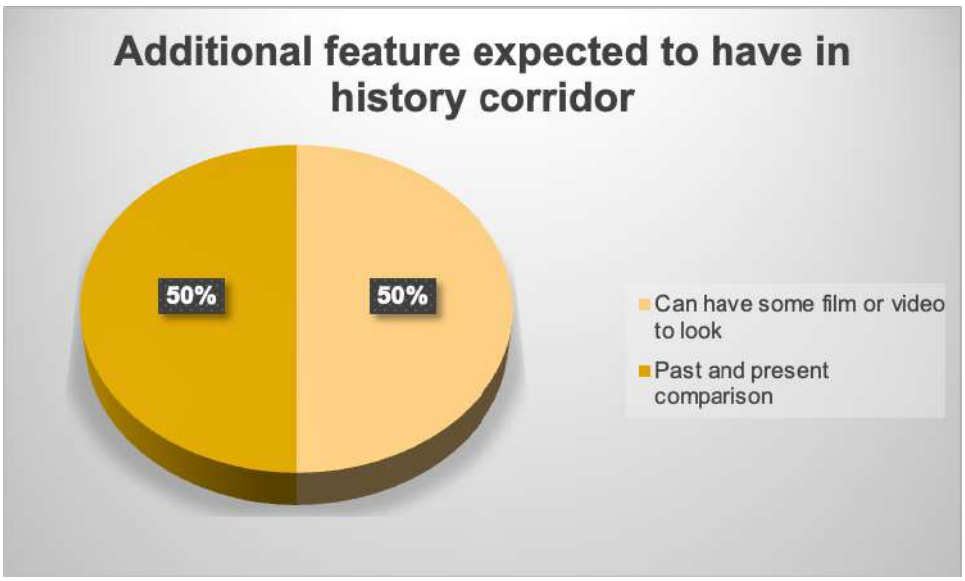


Figure 4.31: Additional feature expected to have in history corridor

As refer to Figure 4.31, 2 of them stated that they wish to have some film or video to look in history corridor and past and present comparison. This suggests that respondents dislike reading texts or sentences which is always used in traditional history corridor. Through leveraging film and video, past and present comparison, the users can have a better understanding and absorption of knowledge as it terminate the boring reading element.

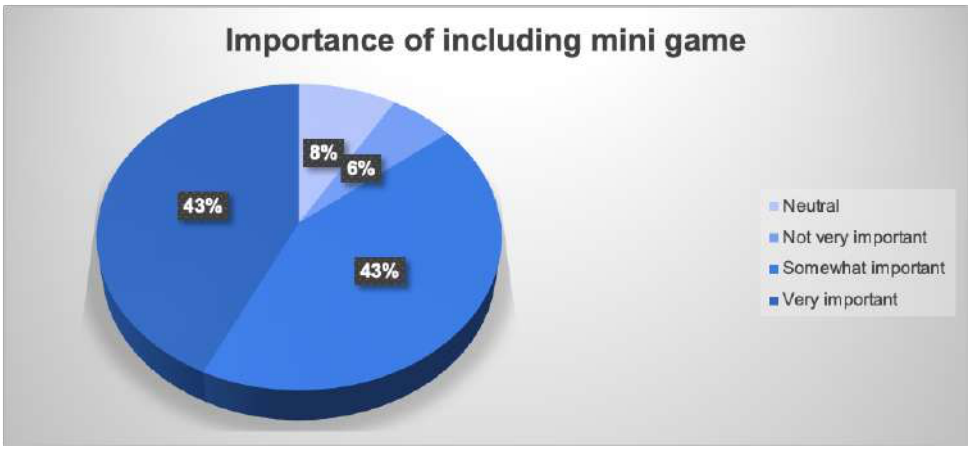


Figure 4.32: Importance of including mini game

As refer to Figure 4.32, respondents who agree it is very important and somewhat important of including mini game contribute to total of 86 percent out of 100 percent. Only 6% of total respondents disagree that it is not very important and 8% has neutral opinion. This suggests that the current generation think that mini game is important in helping strengthening knowledge in oneself. Interactive way of learning is always better than conventional way.

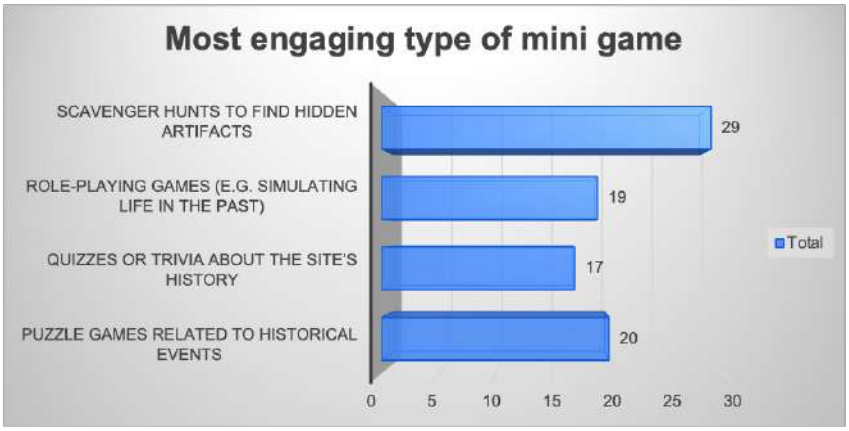


Figure 4.33: Most engaging type of mini game

As refer to Figure 4.33, 29 out of 35 think that most engaging type of mini game is scavenger hunts to find hidden artifacts, 20 out of 35 think that puzzle game related to historical event is most engaging type of mini game, followed by role playing game, and quizzes. These results suggest that future mini-game designs should focus primarily on interactive, exploration-based experiences such as scavenger hunts, with puzzle elements as supportive activities.

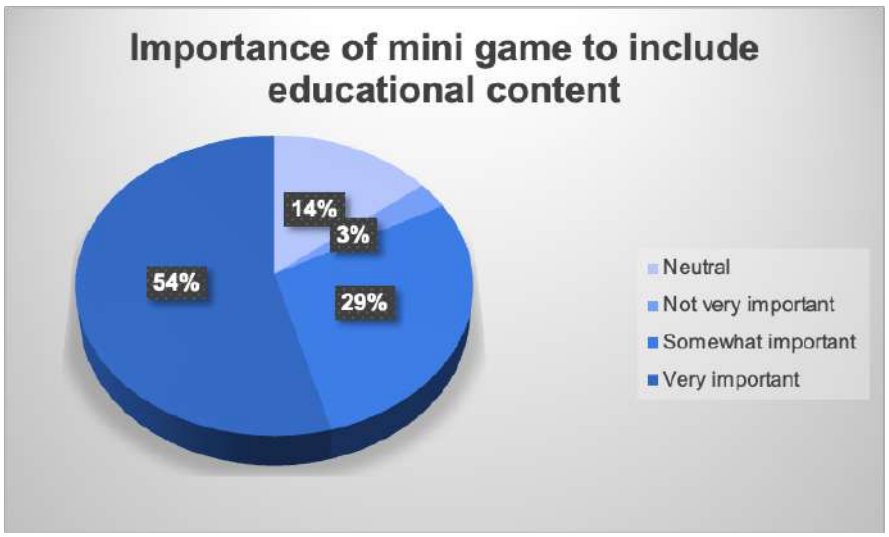


Figure 4.34: Importance of mini game to include educational content

As refer to Figure 4.34, 54% of total respondents think that it is important for mini game to include educational content, 29% of total respondents think that it is somewhat important for mini game to include educational content, 14% of total respondents have neutral opinion, 3% think it is not very important. This

data suggest that respondents prefer mini game to include educational content. This is due to mini game can help in strengthening the knowledge in users, hence increase learnability of knowledge in the system.

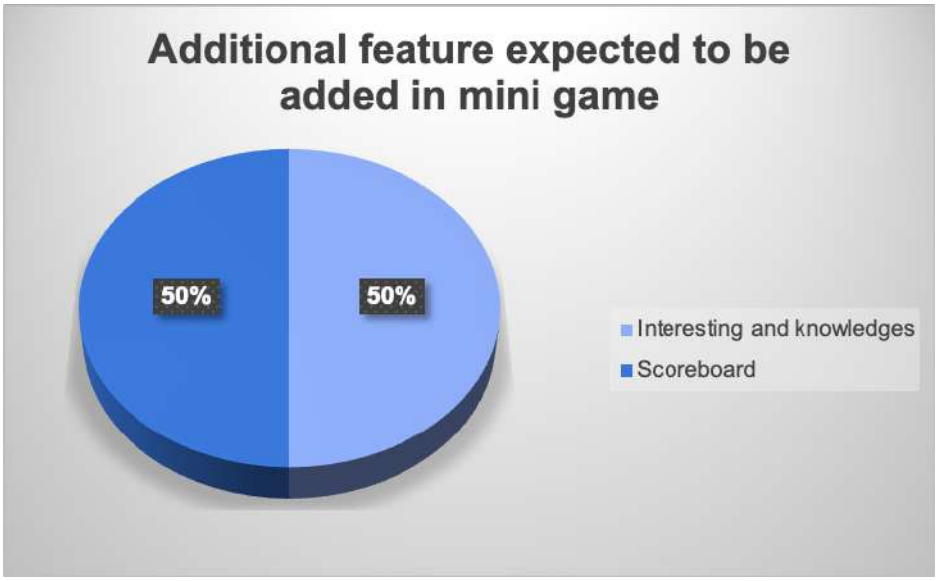


Figure 4.35: Additional feature expected to be added in mini game

As refer to Figure 4.35, 2 respondents suggest that interesting knowledges and scoreboard should be added into the system. This suggest that competitiveness also aid in knowledge consolidation in users. With increase competitiveness, users tend to focus and try harder in order to win in scoreboard, this positive competition improve users' learning process and aid them in learning better.

4.2.1.4 Discussion

Based on the data collected from the 35 participants, several important insights were obtained regarding user needs and expectations for learning historical content interactively. Most of the respondents were between 18 – 30 years old, suggesting that the questionnaire had successfully reach target audiences. Most respondents are familiar with technology, majority have visited a historical site before, indicating prior exposure to the domain. Difficulty understanding historical context, content being boring, and lack of visual / interactive materials are identified main challenges faced. This highlightes the need of a more engaging and immersive learning method.

While many participants used to expose themselves to AR or interactive websites, a portion was still unfamiliar, suggesting that the system should remain user-friendly and provide clear instructions for AR features. Since the participants showed high interest in features such as AR reconstructions, interactive maps, history corridor, storytelling and educational mini games, the author should focus on current track of constructing these modules. Multimedia elements integration is highly important to prevent boredom and loss of attention from user. Storytelling which include personal stories and anecdote from historical figures with the ability to personalize storytelling experience should also be implemented as the participants showed interest in this features. However, the story should be kept short because long story might bore the users.

AR module is expected to have to ability to visualize historical structures and artifacts while showcasing historical periods. Educational content is included to maximize assimilation of knowledge. Interactive map module should provide real-time location tracking accurately. Visited places should be marked. History corridor and mini games are highly favored. Different type of mini game such as scavenger hunt and puzzle game should be implemented.

In summary, the findings strongly support the development of a web-based interactive application that prioritizes engagement, accessibility, and educational value through multimedia and AR integration.

4.2.2 System requirements

4.2.2.1 Software requirements

Table 4.2: Software requirement

Component	Minimum Requirement	Optimum Requirement
Web Browser	Google Chrome, Firefox, Opera, Microsoft Edge, Safari	Google Chrome, Firefox, Opera, Microsoft Edge, Safari
Operating System	Window 10, MacOS 10.13, Android 9, iOS 13	Windows 11, macOS 12+, Android 11+, iOS 15+

Text	Microsoft Word, Notepad	Microsoft Word, Notepad
Audio	Audacity	Audacity
Image	Adobe Photoshop	Adobe Photoshop
Visual Aid	Canvas, Draw.io	Canvas, Draw.io
Video	Capcut	Capcut
2D Animation	Adobe Animate	Adobe Animate
3D Animation	Blender	Blender
Augmented Reality (AR)	Vuforia	Vuforia
Authoring Tools	Unity	Unity

4.2.2.2 Hardware requirements

Table 4.3: Hardware requirements

Component	Minimum Requirement	Optimum Requirement
Processor	Intel Core i3 or equivalent	Intel Core i5
RAM	4GB	8GB
Storage	500MB free space	1GB free space
GPU	Integrated graphics (Intel UHD Graphics)	Dedicated GPU (NVIDEA GTX 1050+)
Internet Connection	5 Mbps	25 Mbps

4.2.2.3 Main development tool

4.2.2.3.1 Authoring tool – Unity

Figure 4.36: Unity logo

Unity is an advanced and popular game development engine that enables developers to create interactive 2D, 3D, and XR (AR/VR) experiences (Arnia, 2022). Unity, which is well-known for its flexibility and real-time rendering capabilities, supports a wide range of platforms, including mobile, desktop, online, and console. Its major programming language is C#, and it has a user-friendly visual editor, making it suitable for both new and experienced developers. Unity has become a popular tool not only for game production, but also for industries such as architecture, automotive, film, and most importantly education which our project are contributing to. All these are available thanks to its strong community, detailed documentation, and vast asset store.

Firstly, Unity's Timeline and Cinemachine tools can help develop scenes which can be choreographed to feel cinematic and dynamic (Unity, no date). Text, background music, voiceover, and visual storytelling can be integrated smoothly, making historical content both easy to follow and engaging. Next, its AR Foundation which support ARK (iOS) and ARCore (Android) can support the build of augmented reality experiences. As a game engine, it also excels in creating educational mini games. The developers can design puzzles, simulation and quizzes with score tracking, animations, and reward systems. Features like physics simulation, user feedback loops, and timers make games more fun and instructive. Unity's versatility ensures the minigames are responsive, aligned with historical themes, and visually appealing. Unity also allows the development of interactive maps with clickable hotspots and dynamic pathfinding. With plugins and custom scripts, Unity can highlight key locations, trigger AR experiences or animations when users reach certain points. This improves spatial understanding and navigation of Lembah Bujang site. To achieve a virtual museum experience, Unity also enables the creation of 3D galleries, where users can walk through a digital corridor and interact with high-fidelity 3D artifacts. It supports rotation, viewing, and zooming objects from all angles. Unity UI system and shader tools allow for overlays with descriptions, audio commentary, and videos, turning stationary objects into rich educational content.

4.2.2.3.2 3D Animation – Blender

Figure 4.37: Blender logo

Blender is a powerful and open-source 3D production tool that is extensively used for modelling, animation, sculpting, texturing, rendering, and visual effects. It can handle the complete 3D workflow, from asset generation to animation and final output (Augurs Technologies, 2023). Blender's strength rests in its adaptability and free availability, making it popular among indie developers, academics, and professionals alike (Qarnot, 2023). It includes a node-based material editor, complex physics simulations, rigging and skinning tools, and robust rendering engines like Eevee and Cycles. Its active development community constantly contributes to plugins, tutorials, and upgrades, keeping it at the cutting edge of 3D technology. Blender's high-quality output and real-time preview capability make it perfect for creating historically accurate images and animations in educational and heritage projects.

Blender is the primary technology chose to develop this educational project is because it can create accurate 3D models of artifacts, old architecture, and animated scenes from the history of Lembah Bujang. These objects can be moulded and textured in depth to resemble authentic archaeological finds before being exported into Unity for further integration. Blender allows the authors to choreograph animations such as traditional rites, daily living routines, and

temple construction to bring the virtual world to life and movement. Its advanced camera tracking and keyframing capabilities make it ideal for creating pre-rendered scenes for storytelling modules. Blender, which supports industry standard file formats such as FBX and OBJ, integrates smoothly with Unity-based processes, bridging the gap between artistic creation and interactive experiences.

4.2.2.3.3 Augmented Reality – Vuforia

Figure 4.38: Vuforia logo

Vuforia is a powerful and widely used augmented reality (AR) software development kit that allows the developers to build interactive and rich AR experiences, particularly when used in combination with Unity (Nikitin, 2020). Known for its precision in recognition and tracking, Vuforia supports multiple types of AR features such as model targets, ground planes, image targets, and object recognition (Johnson, 2024). This SDK works by allowing the camera to detect pre-defined markers or real-world surfaces and then overlay digital content like 3D models or animations onto them in real time. Vuforia is compatible with both Android and iOS devices, making it available to a broader user base, and it functions effectively even in environments with limited internet connectivity which is a very important aspect for heritage sites. Its ability to integrate seamlessly with Unity ensures that developers can build interactive and visually engaging educational applications without needing extensive low-level coding, streamlining the development process.

Vuforia serves as a solid platform for creating location-based AR material as part of the "Immersive Interaction using Augmented Reality with

Exploratory Learning Approach for Lembah Bujang Heritage" project. For example, picture targets might be strategically placed throughout the Lembah Bujang archaeological site, allowing viewers to scan them with mobile devices and quickly experience 3D reconstructions of temples, trading fairs, or everyday life scenes from the past. Model target tracking enables the identification of real-world artefacts, which can be supplemented with animated overlays or descriptive information. Vuforia's extended tracking feature keeps AR material visible even when the marker is out of view, resulting in a seamless and continuous experience. When we combine this with Unity's visual tools and scripting capabilities, Vuforia helps to transform the static heritage site into an interactive educational environment, providing users ability to engage with history in a more meaningful and immersive way.

4.3 Requirements specification

4.3.1 Functional requirements

Table 4.4: Funtional requirement

Module	Functional Requirement ID	Functional Requirement Description
Storytelling module	FR001	The system shall display historical storytelling content for each heritage site.
	FR002	The system shall include multimedia elements in the storytelling.
	FR003	The system shall allow users to personalize storytelling by choosing different character perspectives.
	FR004	The system shall include personal stories or anecdotes from historical figures.
	FR005	The system shall allow users to adjust the pace or flow of the storytelling content.
AR module	FR006	The system shall allow users to visualize 3D reconstructions of historical structures through AR.

	FR007	The system shall display AR scenes representing different historical periods.
	FR008	The system shall allow users to switch between different historical periods.
	FR009	The system shall support basic user interaction with AR objects (e.g., tapping, rotating models).
	FR010	The system shall track and adapt to user device orientation and position.
Interactive map module	FR011	The system shall display an interactive map of the historical site.
	FR012	The map shall allow users to tap locations to view more information.
	FR013	The map shall highlight and record places the user has visited.
	FR014	The system shall allow filtering locations by category.
	FR015	The map shall track and display the user's real-time location if permitted.
History corridor module	FR016	The system shall present a visual timeline showcasing the site's evolution.
	FR017	The system shall allow users to scroll through different time periods interactively.
	FR018	The system shall offer side-by-side comparisons (past vs present views).
	FR019	The system shall integrate multimedia from different centuries.
	FR020	The system shall allow interactive exploration, including tap-to-reveal historical facts.

Mini game module	FR021	The system shall offer quizzes or trivia games about historical knowledge.
	FR022	The system shall provide scavenger hunt mini-games involving virtual artifacts.
	FR023	The system shall include puzzle games related to historical events.
	FR024	The system shall offer role-playing experiences
	FR025	The system shall reward users with points, badges, or progress tracking.

4.3.2 Non-functional requirements

Table 4.5: Non-functional requirement

Module	Non-functional Requirement ID	Non-functional Requirement Description
Storytelling module	UFR001	Storytelling media shall load within 3 seconds after user interaction.
	UFR002	Audio, video, and text elements must synchronize without noticeable delay.
	UFR003	The interface for storytelling must be responsive across mobile and desktop devices.
	UFR004	Storytelling components should maintain a minimum resolution of 720p for multimedia.
	UFR005	Personalized storytelling choices must reflect instantly without page reload.
AR module	UFR006	AR visualizations shall operate at a minimum of 30 FPS.

	UFR007	The AR module shall support Android and iOS smartphones and tablets.
	UFR008	AR educational content must load within 5 seconds of initialization.
	UFR009	The AR experience must adapt to different lighting environments (indoor and outdoor).
	UFR010	The AR module should use lightweight 3D assets (<50MB) to ensure smooth operation.
Interactive map module	UFR011	Interactive maps must render within 5 seconds after selection.
	UFR012	GPS-based location tracking must maintain an accuracy of ±10 meters.
	UFR013	Map updates (e.g., user movement) must refresh every 2 seconds.
	UFR014	The map must be fully functional on both mobile and web platforms.
	UFR015	Interactive maps should maintain visual clarity even on small screens.
History corridor module	UFR016	History Corridor visuals must maintain at least 1080p resolution quality.
	UFR017	Timeline scrolling should maintain smooth animation without freezing (minimum 60 FPS).
	UFR018	Loading between time periods should occur in under 2 seconds.
	UFR019	All history data must be backed up to ensure no data loss.
	UFR020	The module should support progressive loading to optimize performance.
Mini game module	UFR021	Mini-games must load within 5 seconds.

	UFR022	Gameplay must achieve a frame rate of at least 30 FPS.
	UFR023	Score updates must be reflected immediately (within 1 second).
	UFR024	Mini-games should remain accessible even with temporary internet disconnections.
	UFR025	All mini-games must be accessible on both smartphones and desktop browsers.

4.4 System flow diagram

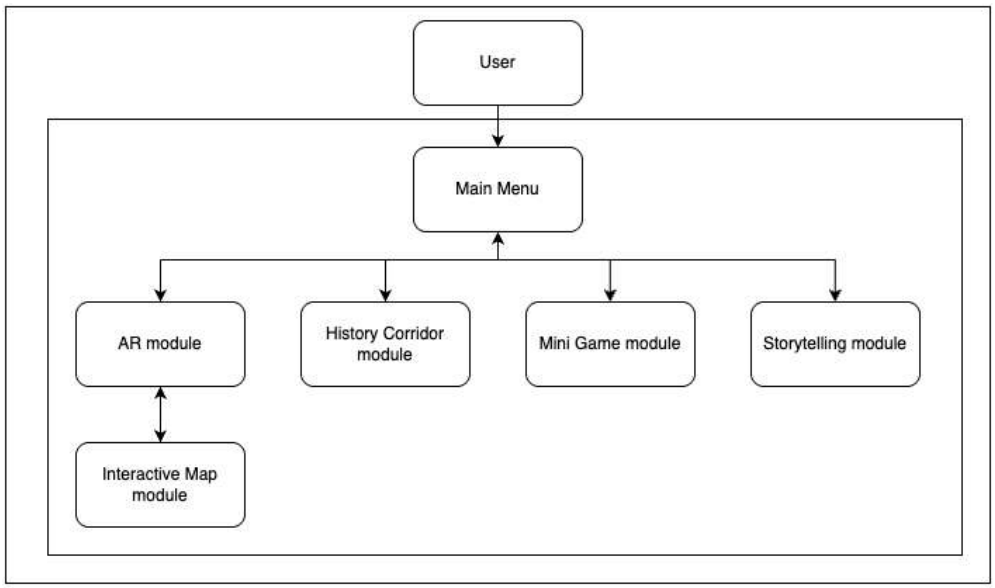


Figure 4.39: System flow diagram

4.5 Storyboard design

4.5.1 Main menu interface

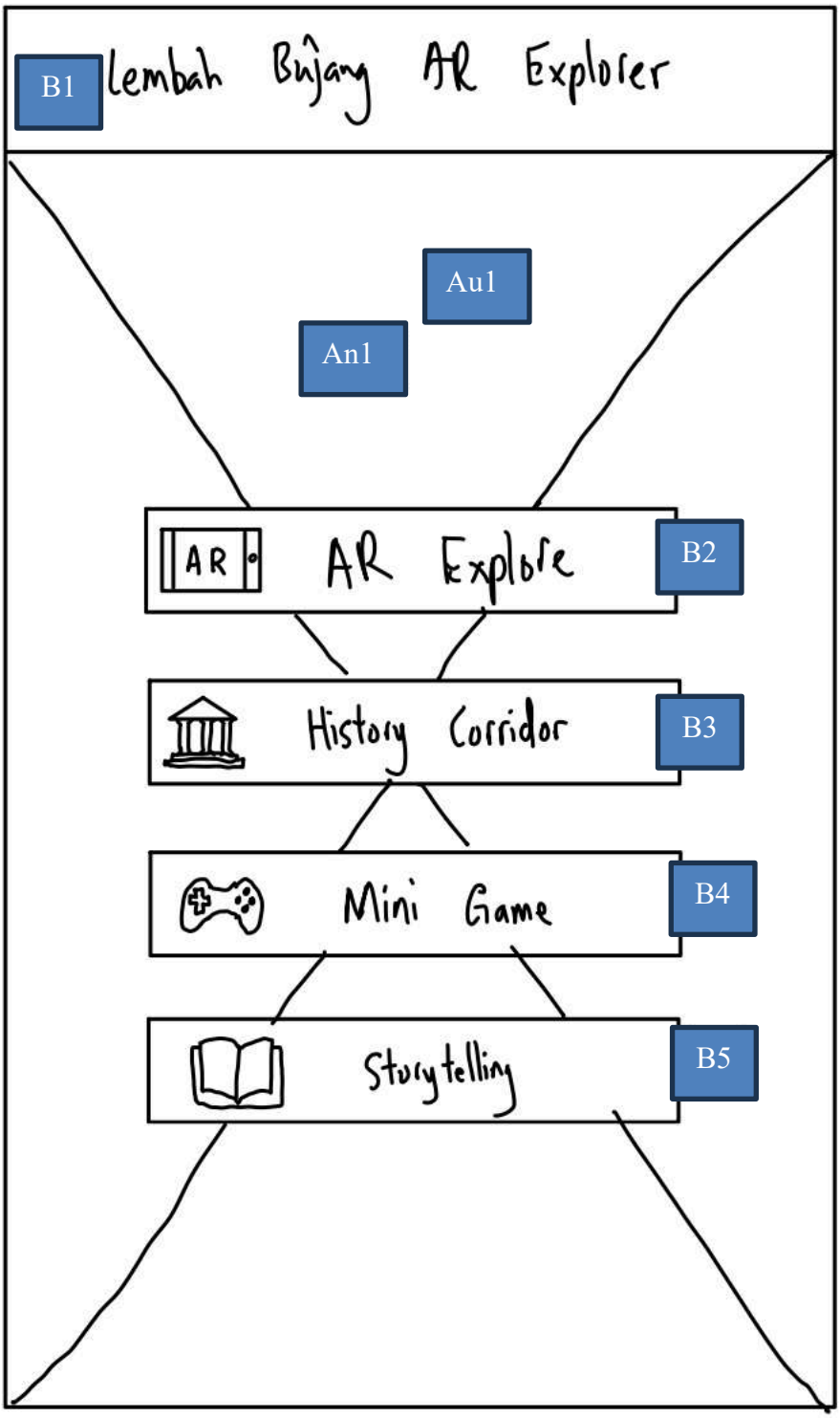
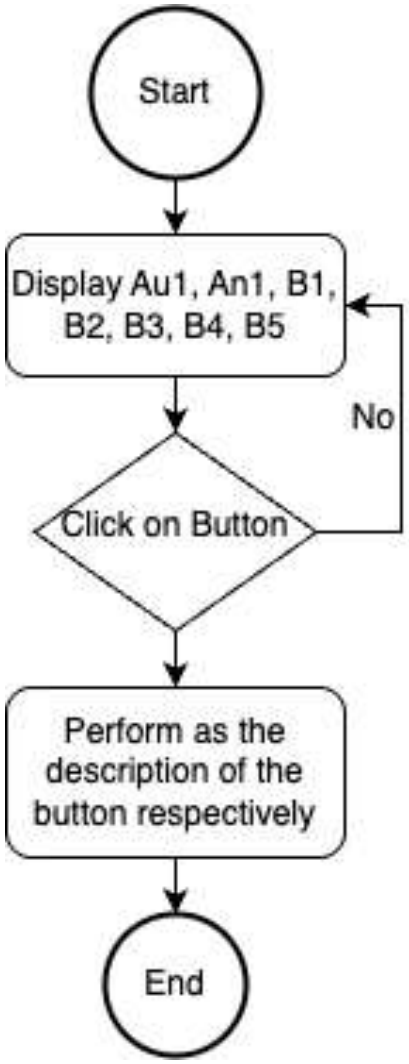


Figure 4.40: Storyboard of main menu

Table 4.6: Description for main menu storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
An1: An1 is the animation on Main Menu. Au1: Au1 is the background music played on Main Menu. B1:B1 is button that navigate the user back to main menu. B2: B2 is button that navigate the user to AR exploration of Lembah Bujang. B3: B3 is button that navigate the user to history corridor of Lembah Bujang. B4: B4 is button that navigate the user to mini game module. B5: B5 is button that navigate the user to storytelling module.	

4.5.2 Storytelling main interface

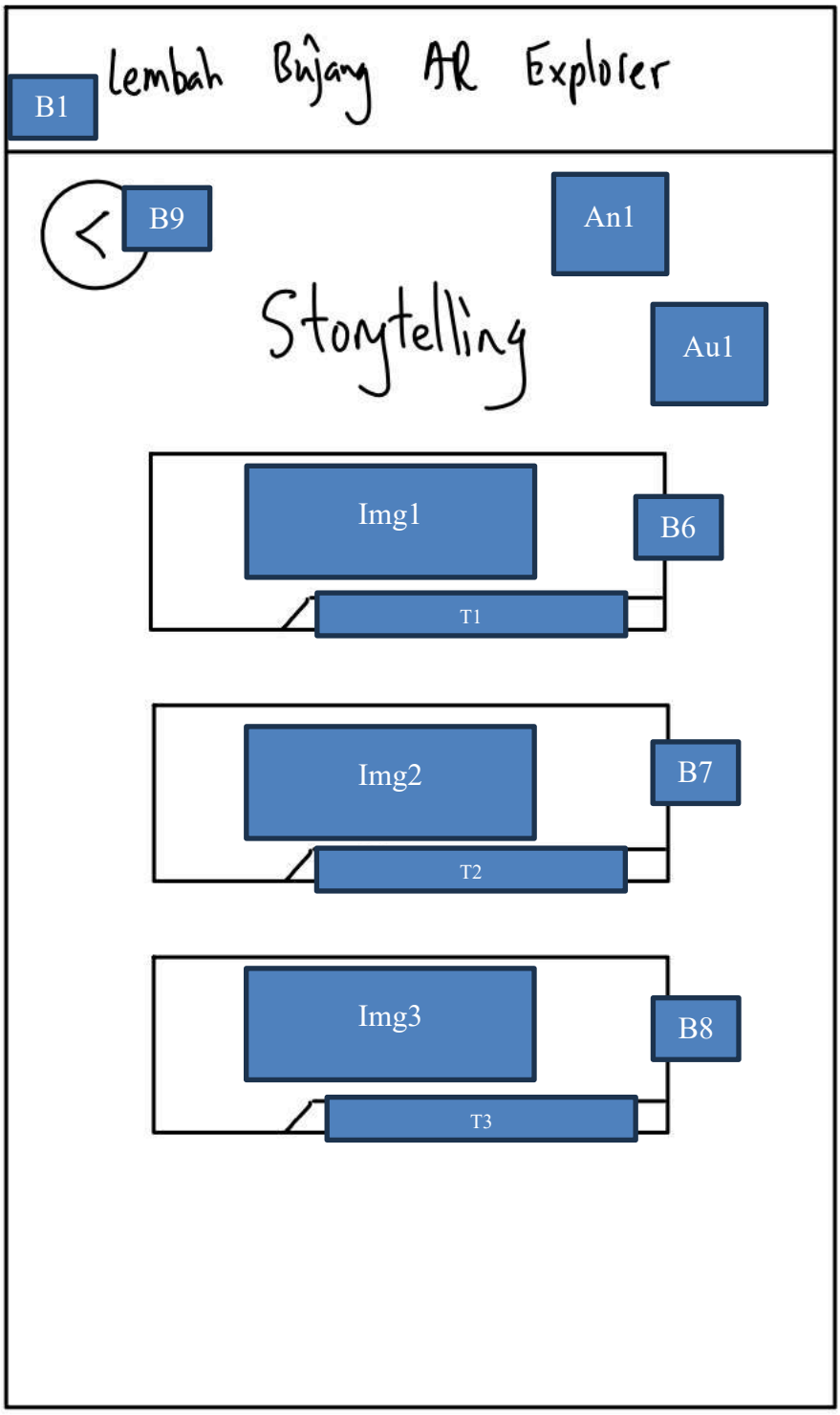
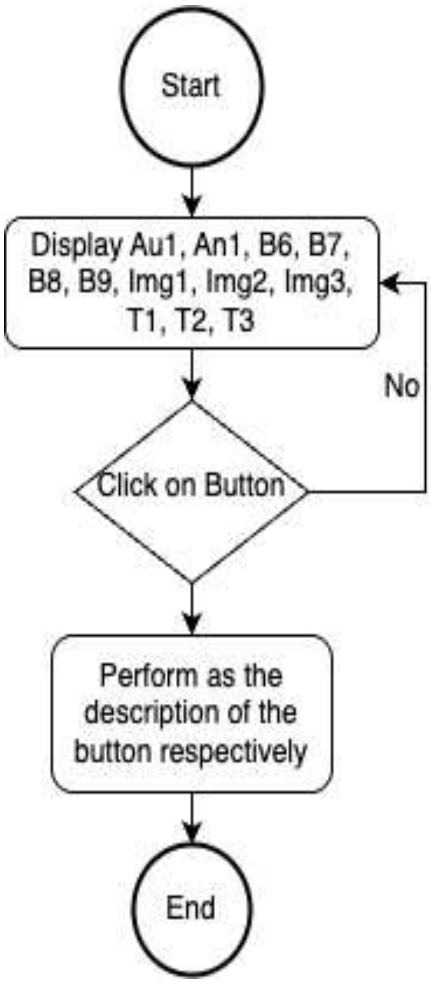


Figure 4.41: Storyboard of storytelling main interface

Table 4.7: Description for storytelling main interface storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
An1: An1 is the animation on Main Menu. Au1: Au1 is the background music played on Main Menu. B1:B1 is button that navigate the user back to main menu. B6: B6 is button that navigate the user to story 1. B7: B7 is button that navigate the user to story 2. B8: B6 is button that navigate the user to story 3. B9: B9 is button that navigate the user to previous page. Img1: Img1 is image displayed in Button 6. Img2: Img2 is image displayed in Button 7. Img3: Img3 is image displayed in Button 8. T1: T1 is text shown in Button 6.	

T2: T2 is text shown in Button 7. T3: T3 is text shown in Button 8.	

4.5.3 Story interface

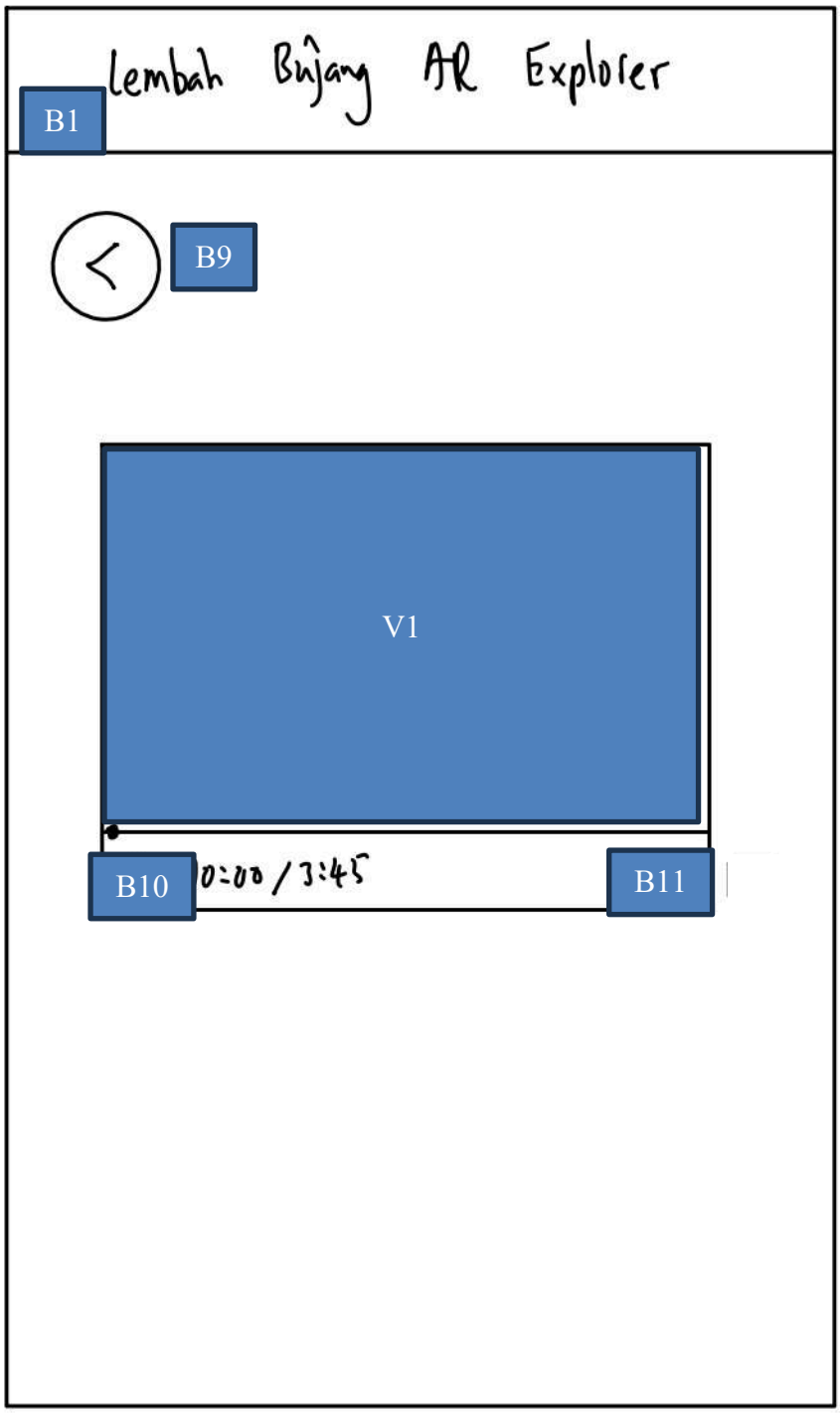
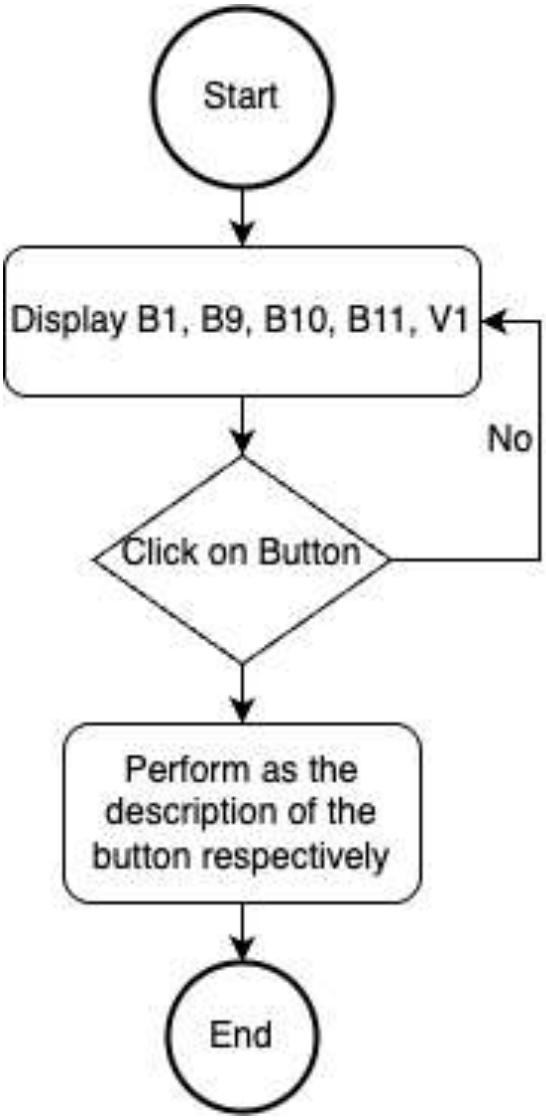


Figure 4.42: Storyboard of story interface

Table 4.8: Description for story interface storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
B1:B1 is button that navigate the user back to main menu. B9: B9 is button that navigate the user to previous page. B10: B10 is button that toggle play or pause of the video. B11: B11 is button that make the video full screen mode. V1: V1 is video played telling the story of the user clicked in.	

4.5.4 Mini game interface

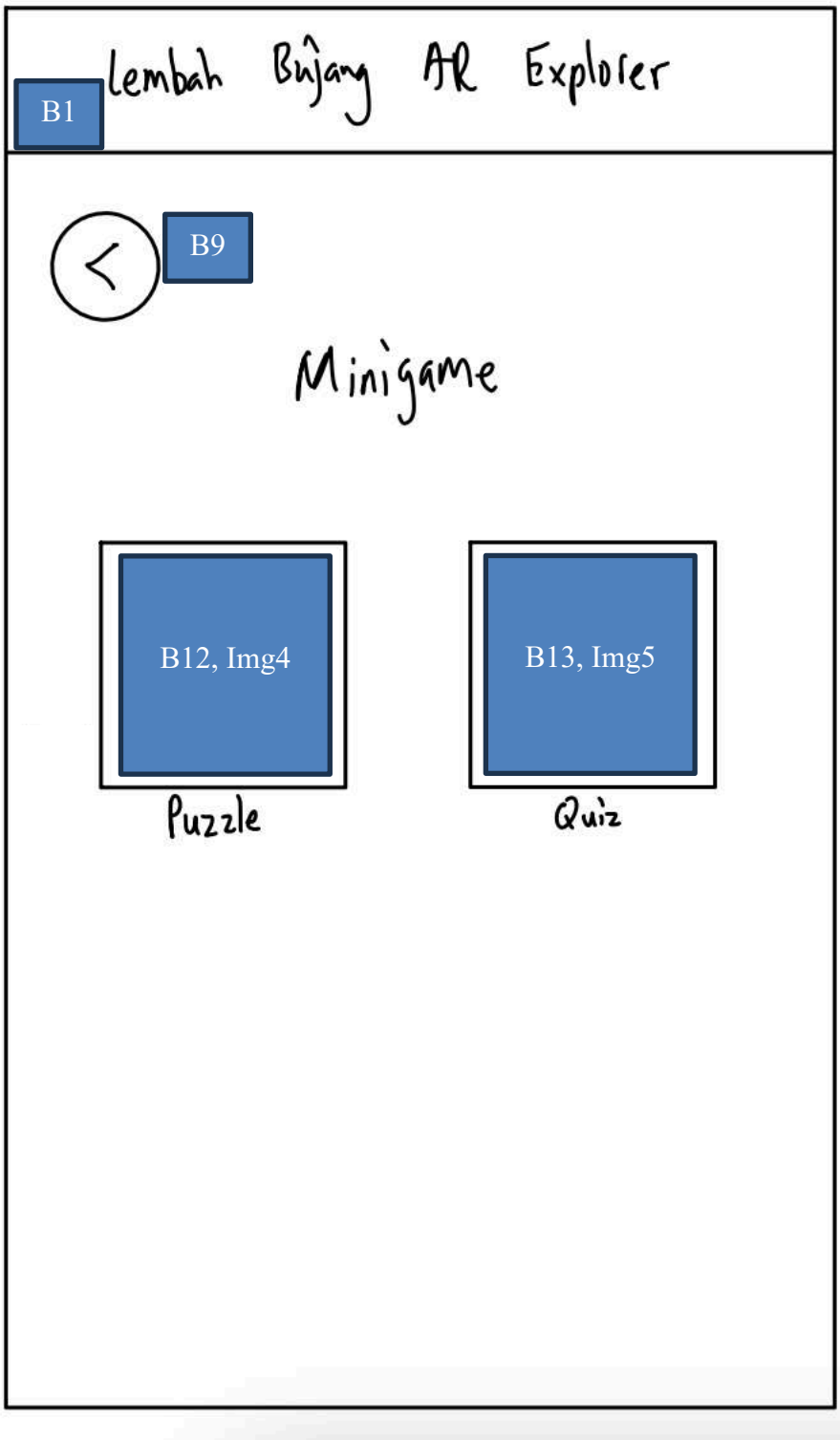
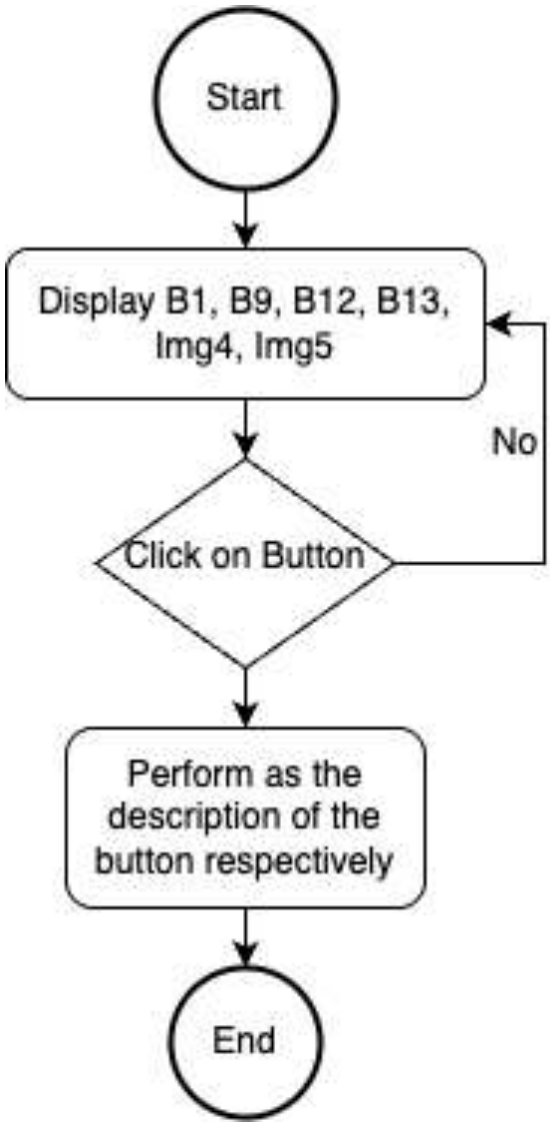


Figure 4.43: Storyboard of mini game interface

Table 4.9: Description for mini game interface storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
B1:B1 is button that navigate the user back to main menu. B9: B9 is button that navigate the user to previous page. B12: B12 is button that navigate the user to puzzle game. B13: B13 is button that navigate the user to quiz. Img4: Img4 is image that show puzzle icon. Img5: Img5 is image that show quiz icon.	

4.5.5 Puzzle interface

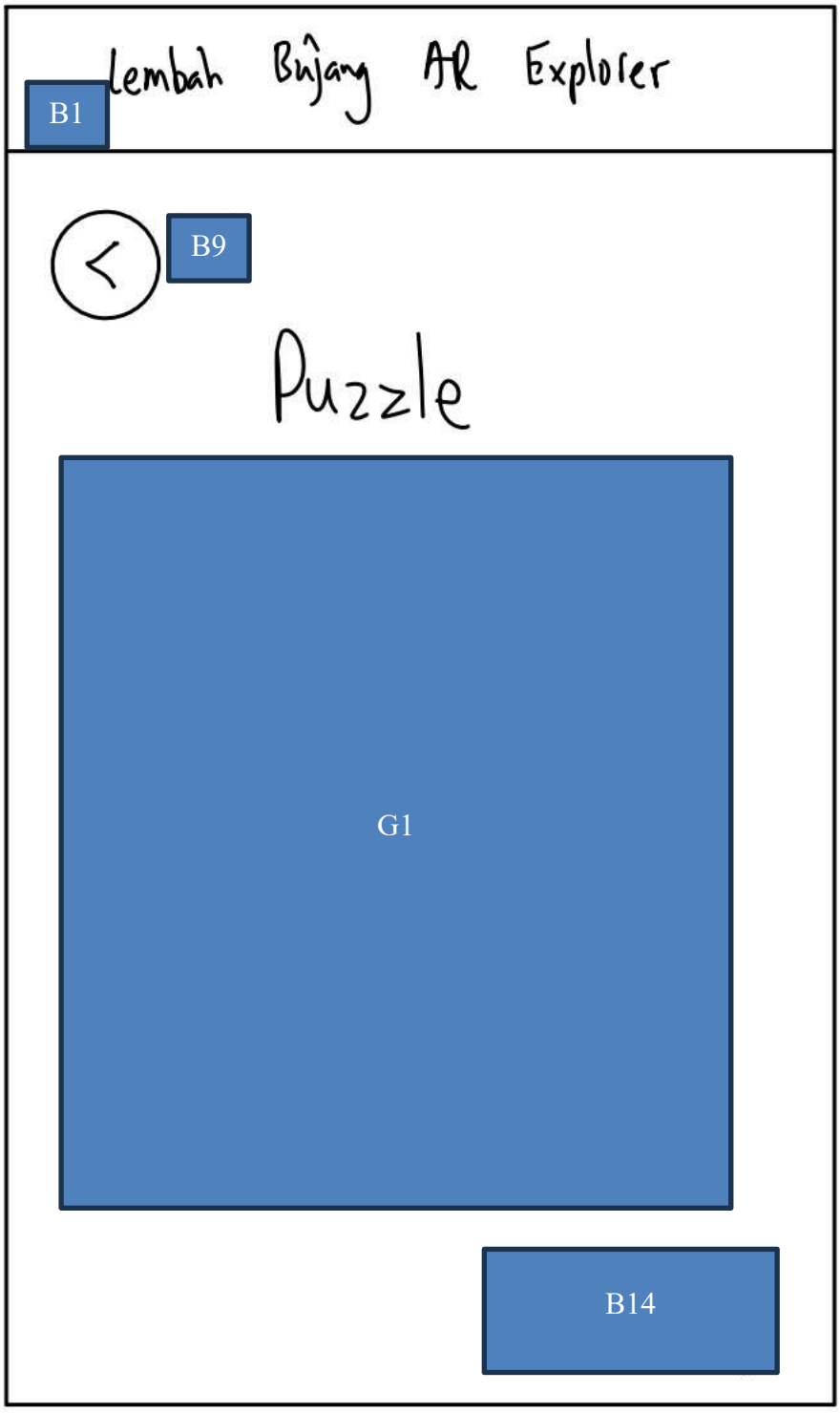
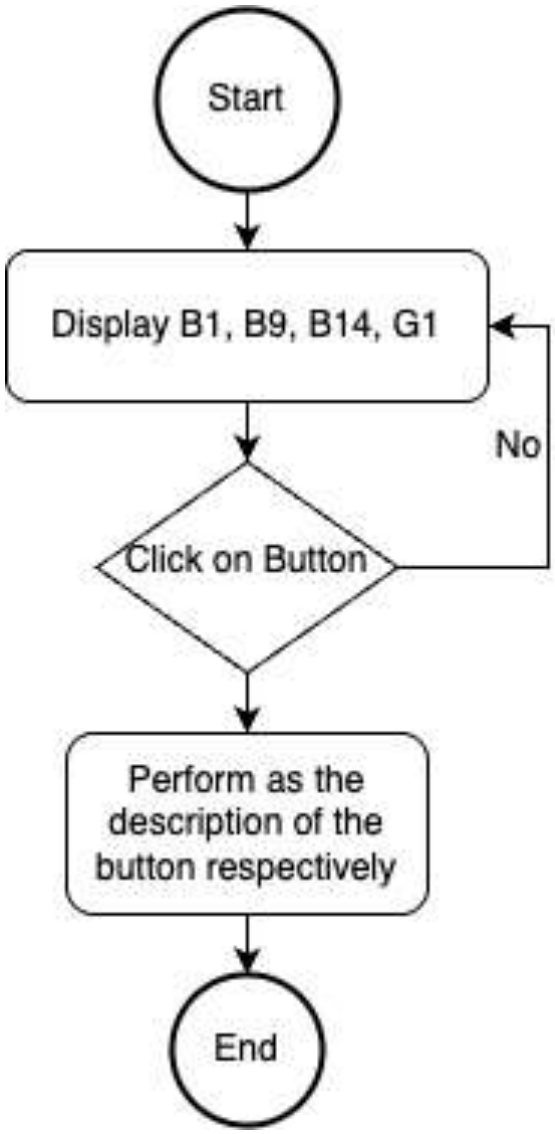


Figure 4.44: Storyboard of puzzle interface

Table 4.10: Description for puzzle interface storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
B1:B1 is button that navigate the user back to main menu. B9: B9 is button that navigate the user to previous page. B14: B13 is button that navigate the user to quiz. G1: G1 is puzzle game which allow user to drag puzzle to correct position.	

4.5.6 Quiz interface

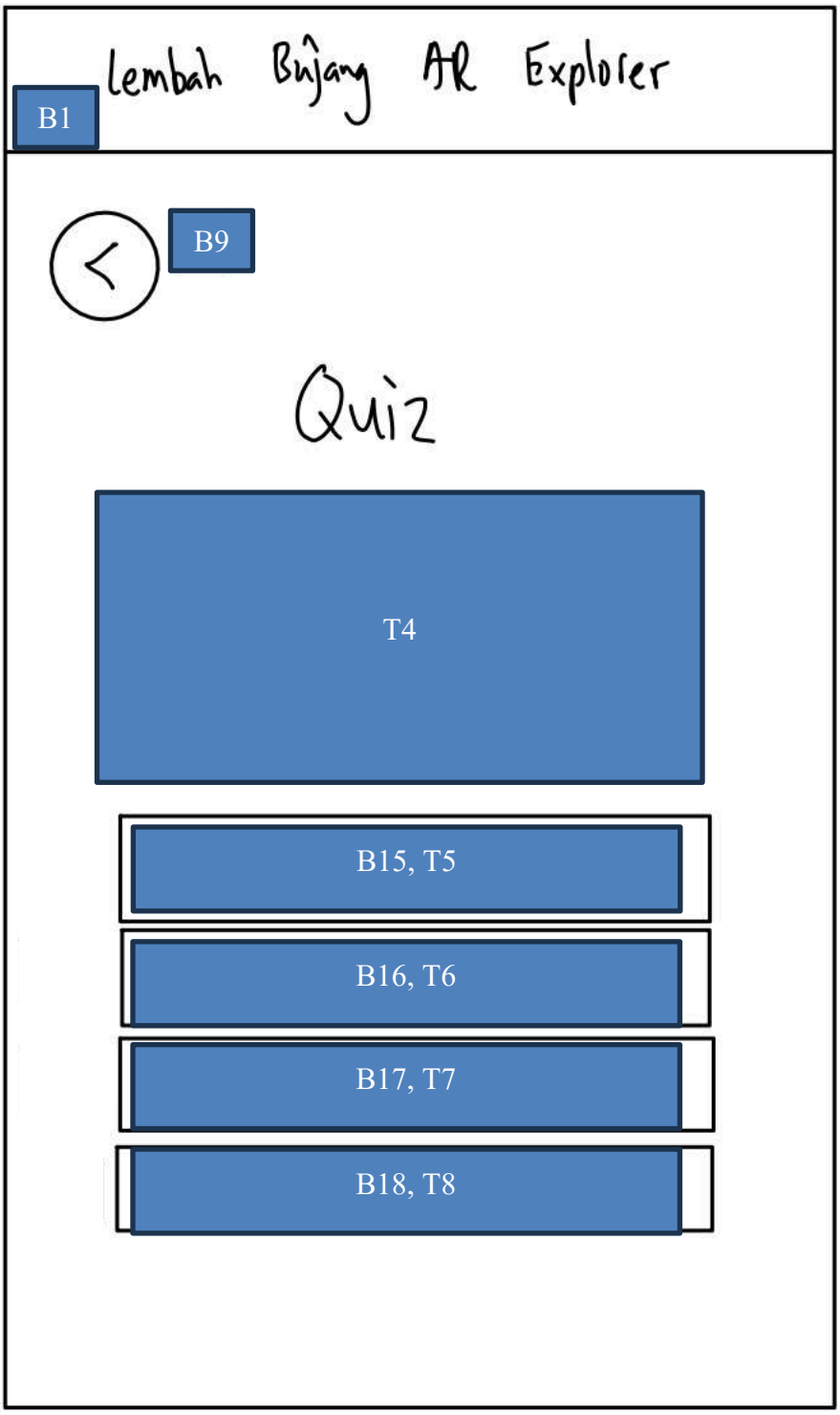
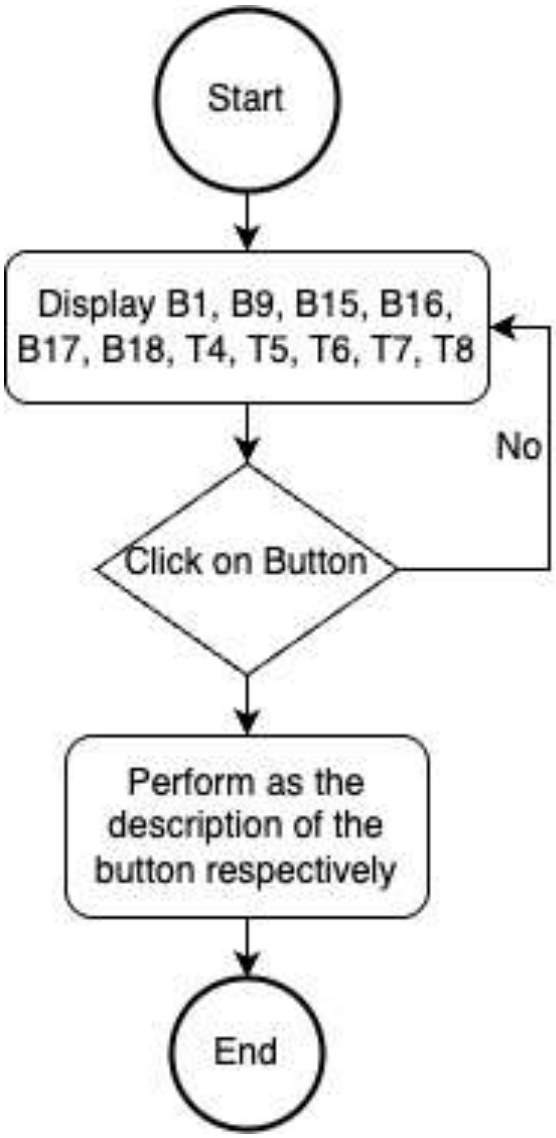


Figure 4.45: Storyboard of quiz interface

Table 4.11: Description for quiz interface storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
B1:B1 is button that navigate the user back to main menu. B9: B9 is button that navigate the user to previous page. B15: B15 is button that enable user to choose Answer A. B16: B16 is button that enable user to choose Answer B. B17: B17 is button that enable user to choose Answer C. B18: B18 is button that enable user to choose Answer D. T4: T4 is text that display the question of quiz. T5: T5 is text that display the answer A.	

T6: T6 is text that display the answer B. T7: T7 is text that display the answer C. T8: T8 is text that display the answer D.	

4.5.7 History corridor interface

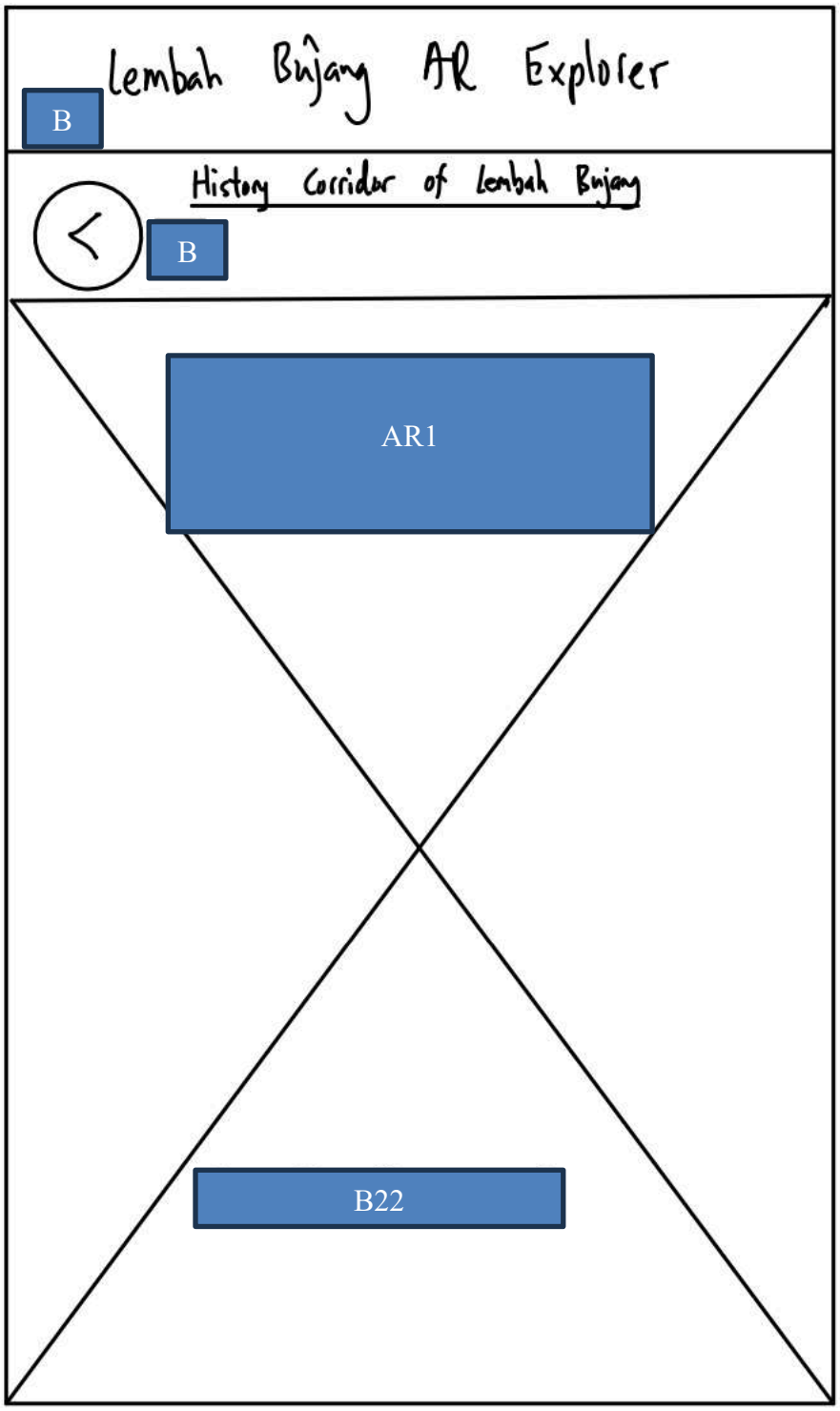
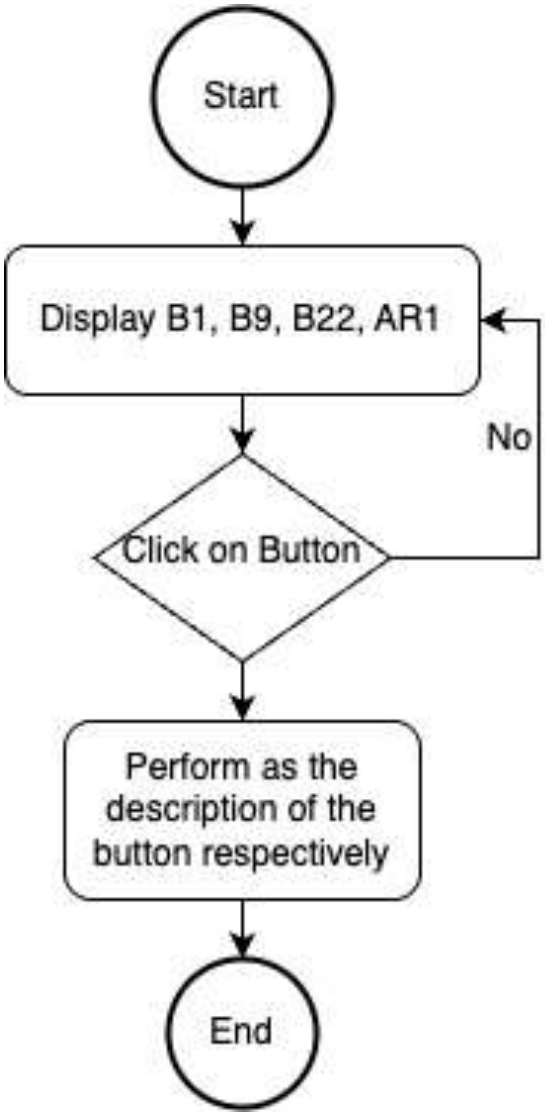


Figure 4.46: Storyboard of history corridor interface

Table 4.12: Description for history corridor interface storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
B1:B1 is button that navigate the user back to main menu. B9: B9 is button that navigate the user to previous page. B22: B22 is button that enable user to choose timeline. AR1: AR1 is augmented reality that show the history corridor.	

4.5.8 AR interface

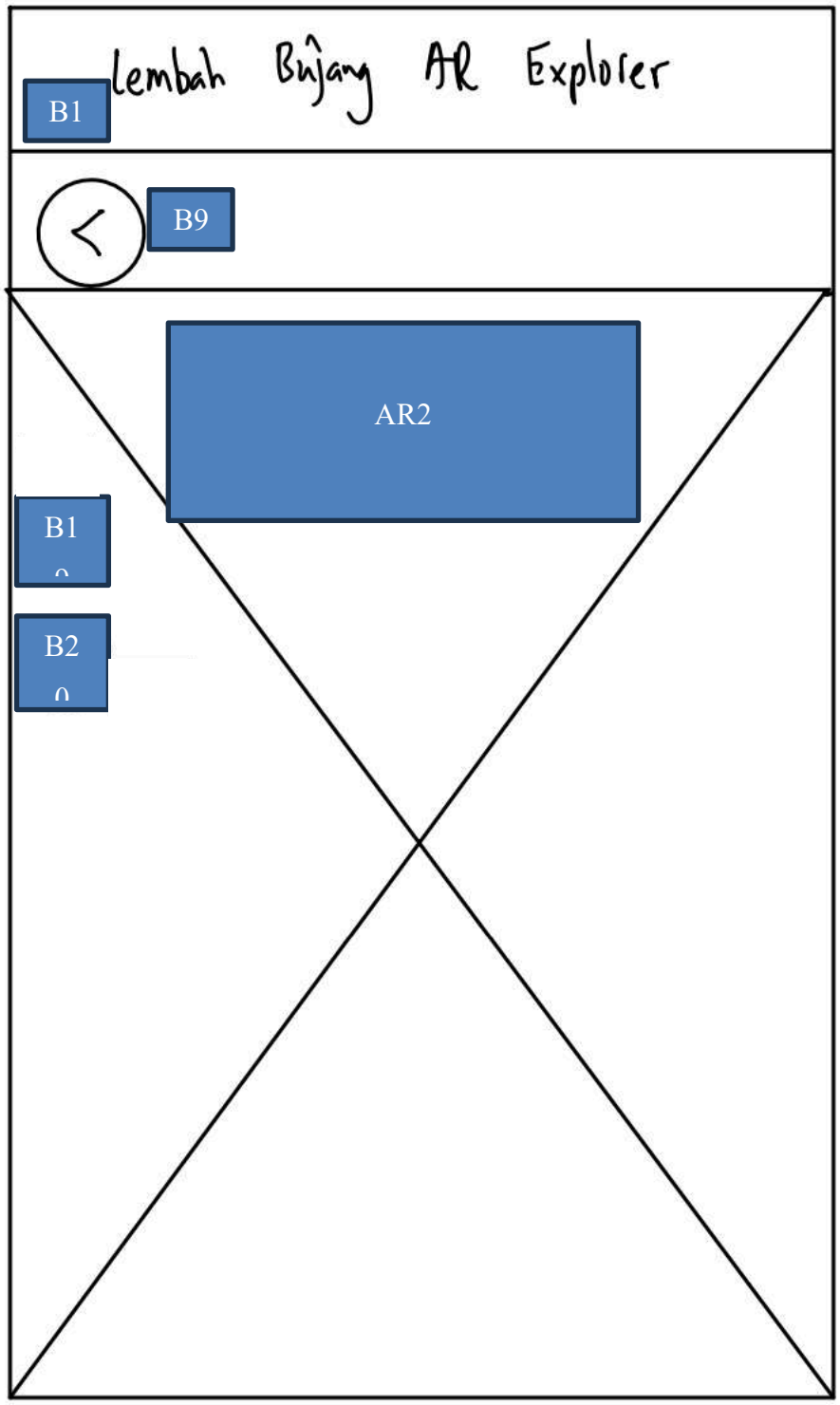
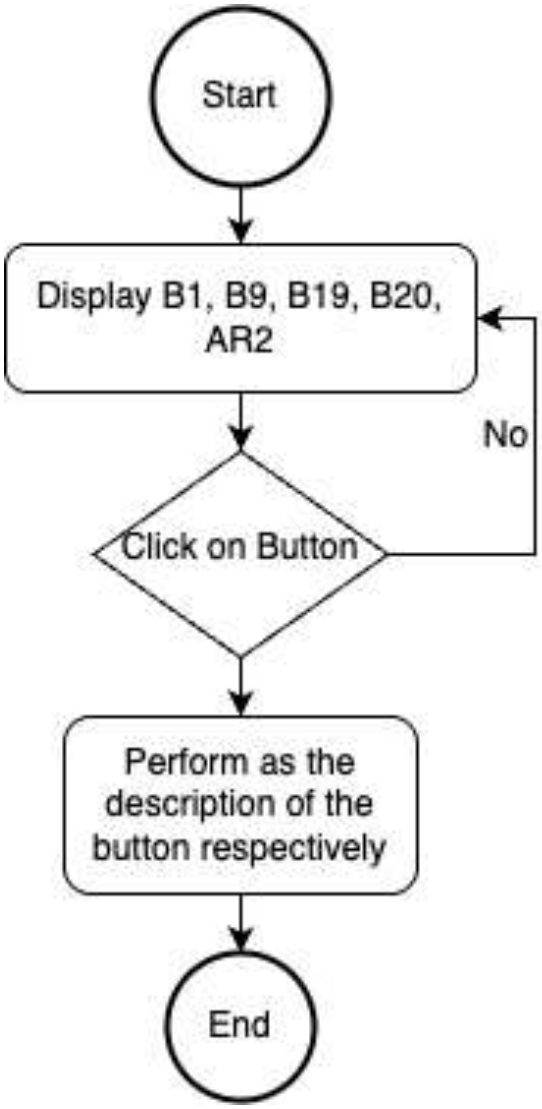


Figure 4.47: Storyboard of AR interface

Table 4.13: Description for AR interface storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
B1:B1 is button that navigate the user back to main menu. B9: B9 is button that navigate the user to previous page. B19: B19 is button that open interactive map. B20: B20 is button that enable user to toggle background music. AR2: AR2 is augmented reality that show the Lembah Bujang.	

4.5.9 Interactive map interface

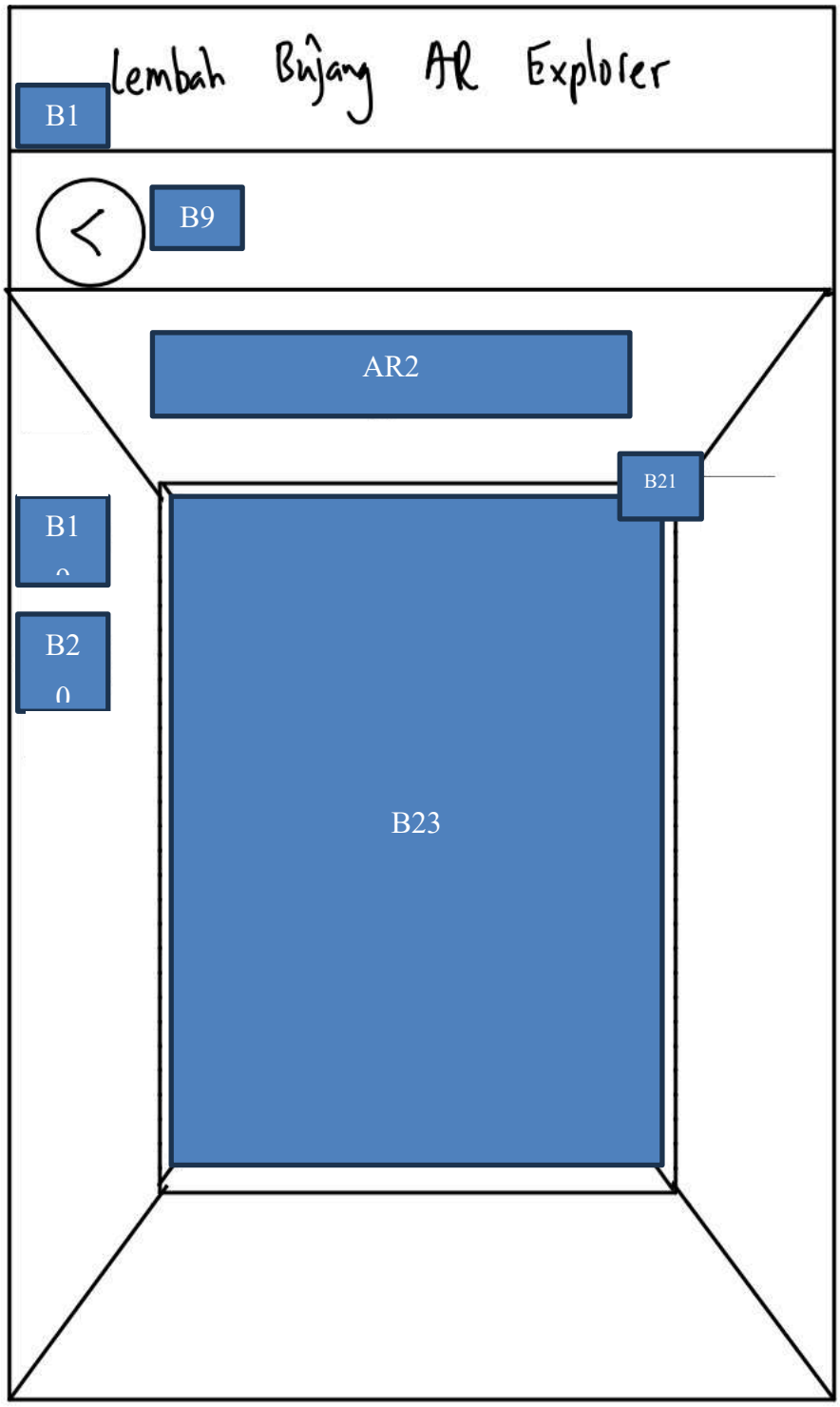
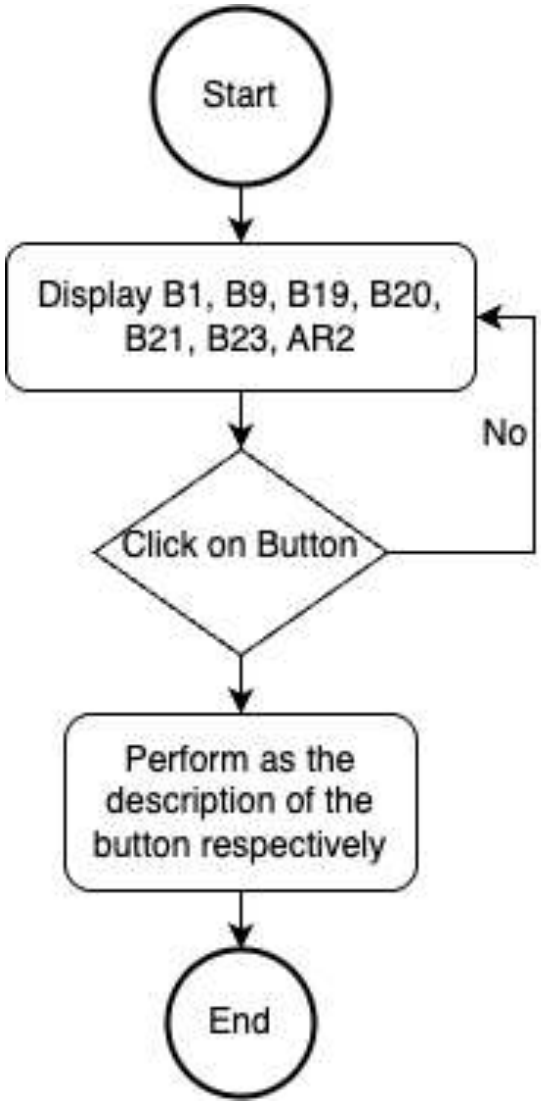


Figure 4.48: Storyboard of interactive map interface

Table 4.14: Description for interactive map interface storyboard

Instruction for Texts, Graphics, Audios, Animation and Buttons	Flow chat for Texts, Graphics, Audios, Animation and Buttons
B1:B1 is button that navigate the user back to main menu. B9: B9 is button that navigate the user to previous page. B19: B19 is button that open interactive map. B20: B20 is button that enable user to toggle background music. B21: B20 is button that enable user to close interactive map. B23: B20 is button that enable user to navigate to desired location. AR2: AR2 is augmented reality that show the Lembah Bujang.	

CHAPTER 5

DEVELOPMENT

5.1 Overview

The development includes 5 main modules, they are AR module, interactive map module, history corridor module, mini game module, and storytelling module. Each designed to enhance user interaction and provide an immersive learning experience. AR is constructed using Blender, Unity and Vuforia. Whereas the frontend is configured in React.JS framework while backend is configured using ASP.NET framework.

Together, these modules create a holistic platform that blends education with interactivity, promising the outcome from exploratory learning approach, ensuring that users not only learn about the site but also experience it in a meaningful and engaging way.

5.2 Development process

5.2.1 AR module

The AR module start with 3D model construction. Blender is used for the 3D construction of the ruin and the how it used to be.

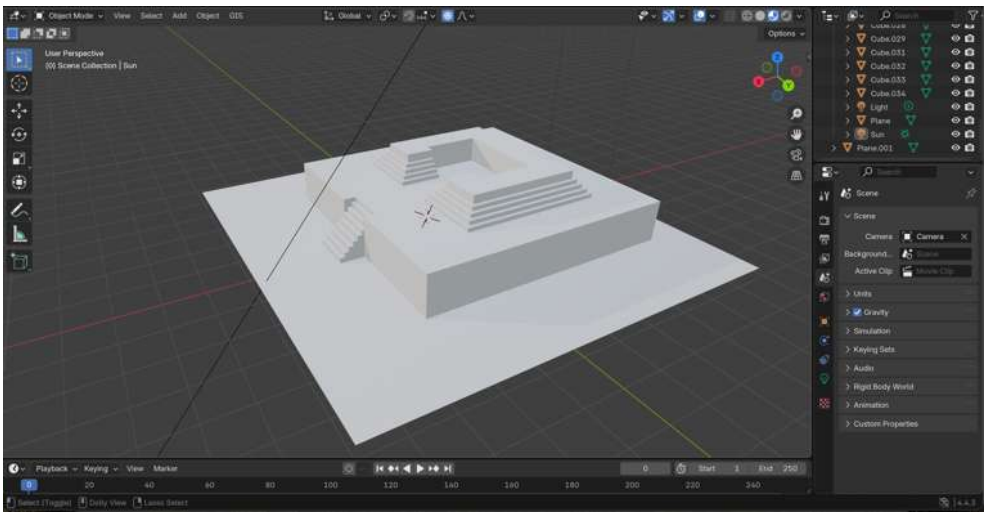


Figure 5.1: First construction of 3D ruin

The figure 5.1 shown above is the 3D reconstruction model based on online resources. Combination of plane and cube is used to construct this ruin.

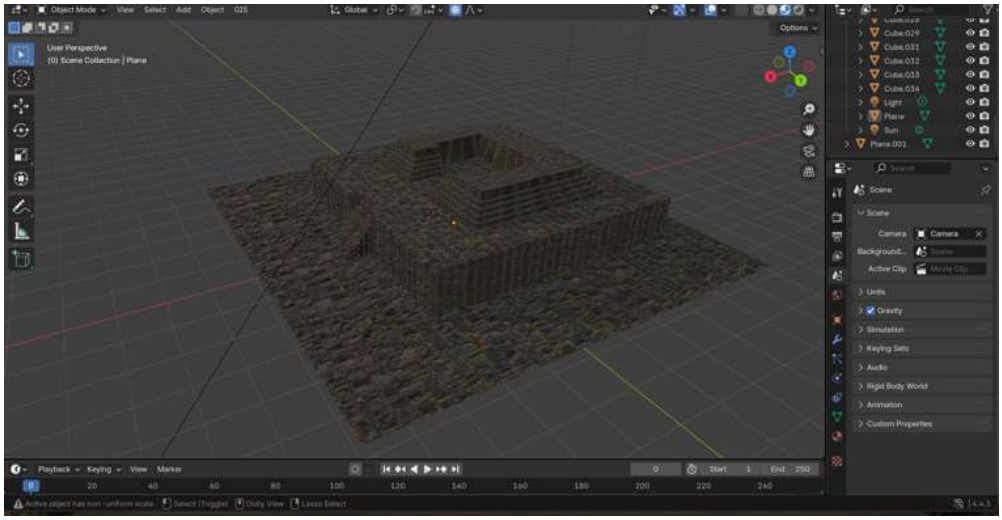


Figure 5.2: 3D construction of ruin after applying texture

The figure 5.2 above is the 3D reconstruction of ruin with texture applied.

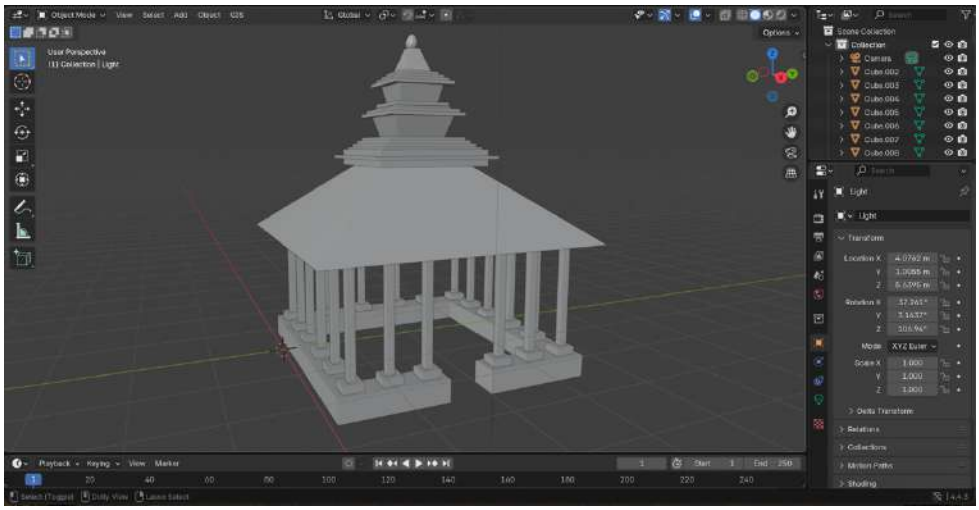


Figure 5.3: 3D reconstruction of full architecture

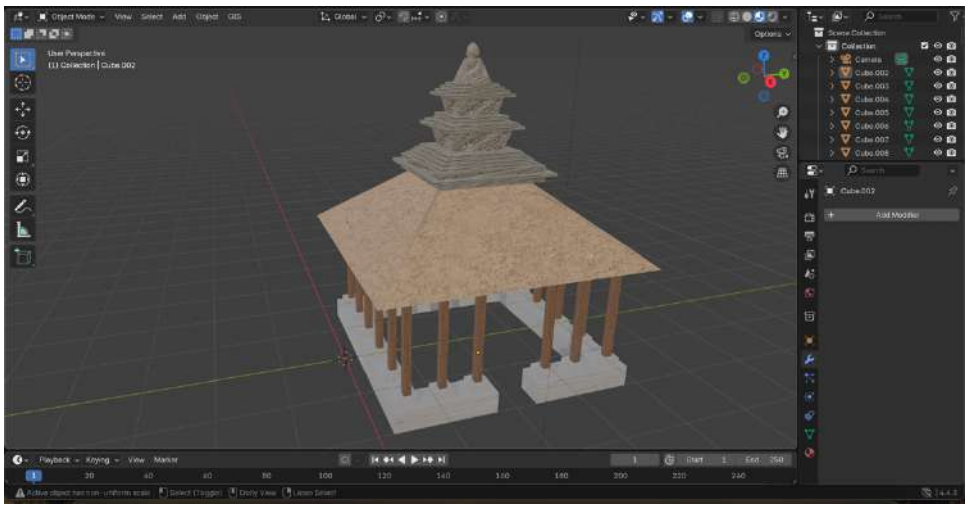


Figure 5.4: 3D construction of full construction after applying texture

The figures above is the 3D reconstruction of how it used to be with and without texture applied. Once they are done, they are exported as .fbx extension. Then, different angle of ruin is snapped to act as the image target. Both images and 3D construction are imported to Unity for AR features.

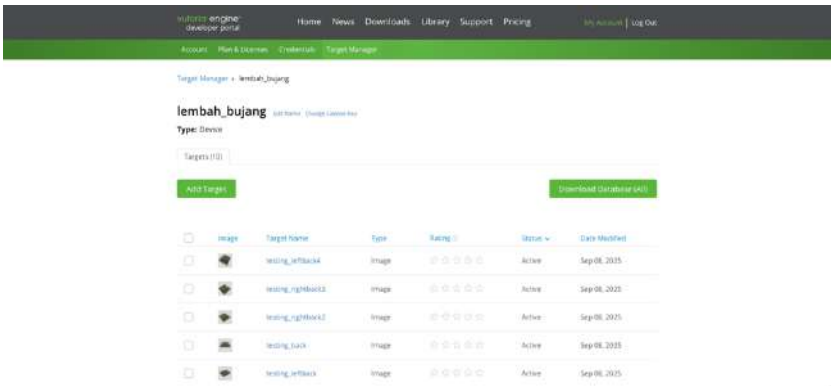


Figure 5.5: Vuforia database

Vuforia is used for AR functionalities, a database is created and the images of different angle taken from the 3D ruin construction is imported into this database as shown in the figure above. Then the database is exported to be used in Unity for image target reference.

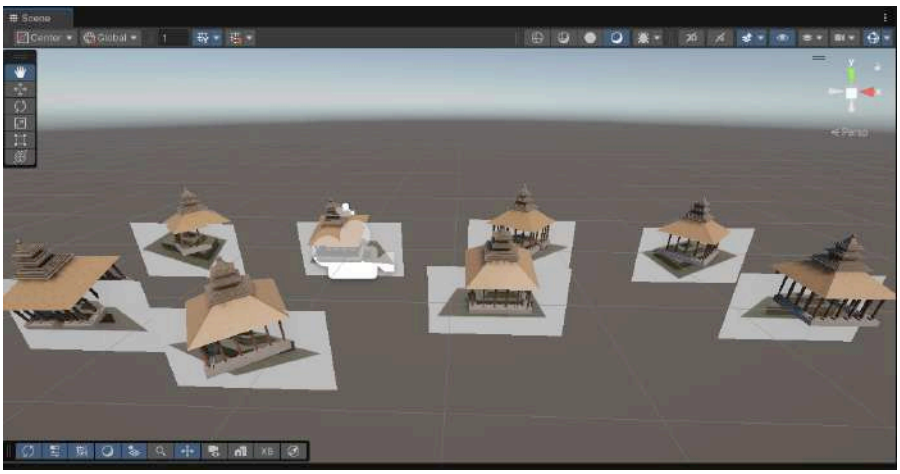


Figure 5.6: AR development using 3D model from Blender

The 3D reconstruction model are match according to the images of different angles as shown in the figures with the aid of database from Vuforia. Then it is ready to be exported.

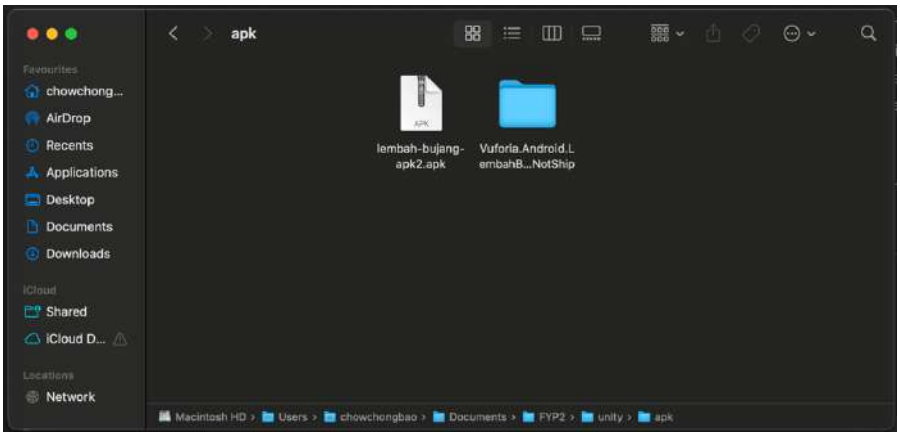


Figure 5.7: APK built from Unity

The project is exported as APK and installed in an Android phone.

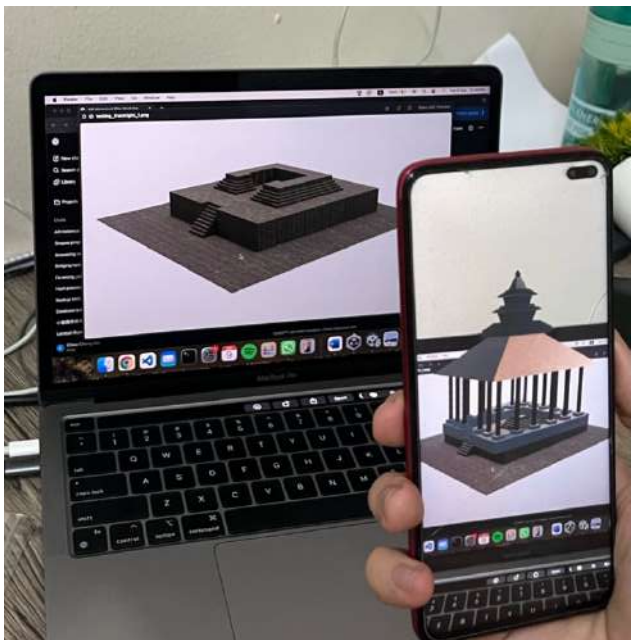


Figure 5.8: Sample of application usage

5.2.2 Interactive map module

Figure 5.9 AR object detection page

When the user click the black button at the top of the page, an interactive map with buttons will be shown, the users are allowed to click any angle they prefer, to look at the heritage.

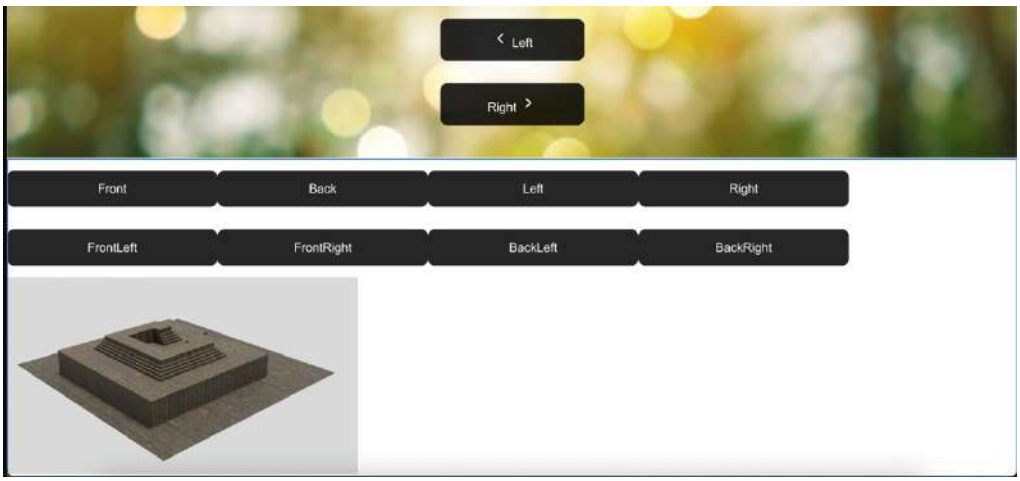


Figure 5.10: Interactive map

Figure 5.10 show the available buttons for the users to choose for AR view. When the user click on a button, the desired angle is shown, then the user can use the phone to see the AR feature.

5.2.3 History corridor module

Figure 5.11: History corridor data code

```jsx
const TimelineCard = ({ period, title, description }) => {
  return (
    <div className="timeline-card p-6 m-4 rounded-lg max-w-md mx-auto">
      <h3 className="text-xl font-bold text-[#d4a017]">{period}</h3>
      <h4 className="text-lg font-semibold mt-2">{title}</h4>
      <p className="text-sm mt-2">{description}</p>
    </div>
  );
};

export default function HistoryCorridor() {
  const navigate = useNavigate();
  return (
    <div className="app-container">
      <button className="back-button" onClick={() => navigate('/')}>⬅️</button>
      <h1 className="text-4xl font-bold mb-8 text-[#d4a017]">
        The Glorious Lembah Bujang Kingdom
      </h1>
      <div className="scroll-container w-full max-w-2xl">
        {timelineData.map((event, index) => (
          <TimelineCard
            key={index}
            period={event.period}
            title={event.title}
            description={event.description}
          />
        ))}
      </div>
    </div>
  );
};
```

Figure 5.12: Code of history corridor page display

The timeline is hardcoded into the system, where each timeline is wrapped into a timeline card and displayed in the page.

Figure 5.13: History corridor page output

5.2.4 Mini game module

Mini game module is further separated into two more module, they are puzzle games and quizzes.

5.2.4.1 Puzzle game

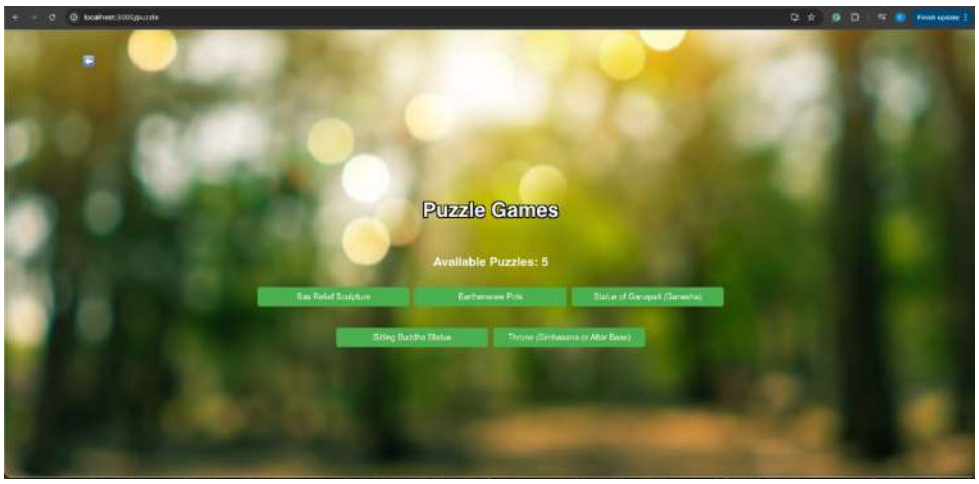


Figure 5.14: Puzzle game selection page

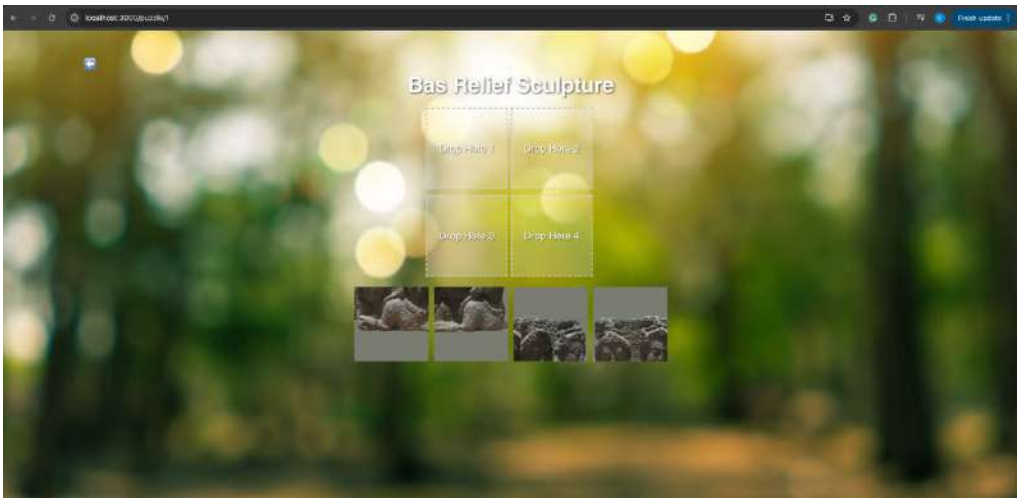


Figure 5.15: Puzzle gameplay page

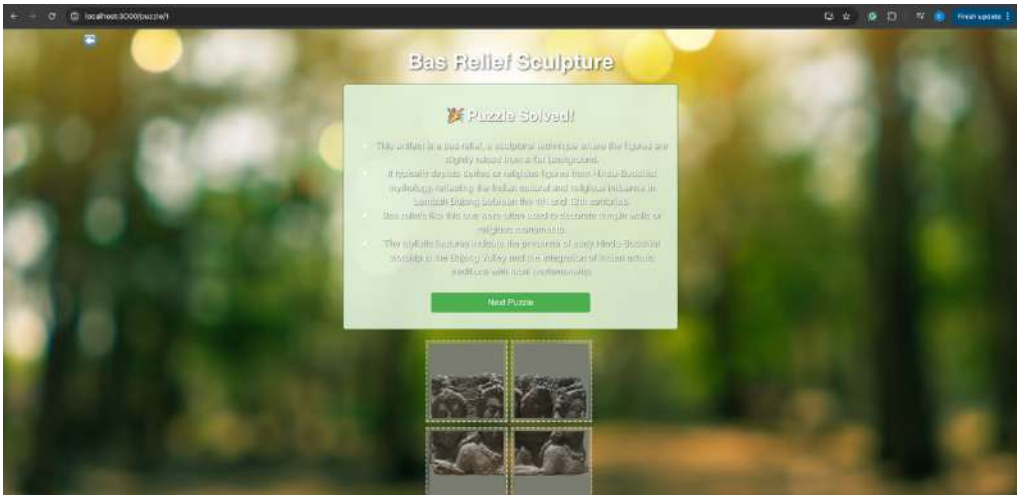


Figure 5.16: Puzzle gameplay solved page

The user is allowed to try and error until the correct pattern is put. Then, a congratulation message and some information regarding the artifact will be shown. The user can then click ‘Next Puzzle’ to proceed to the next puzzle.

Figure 5.17: Code of Puzzle model

This is achieved by firstly declared the model.

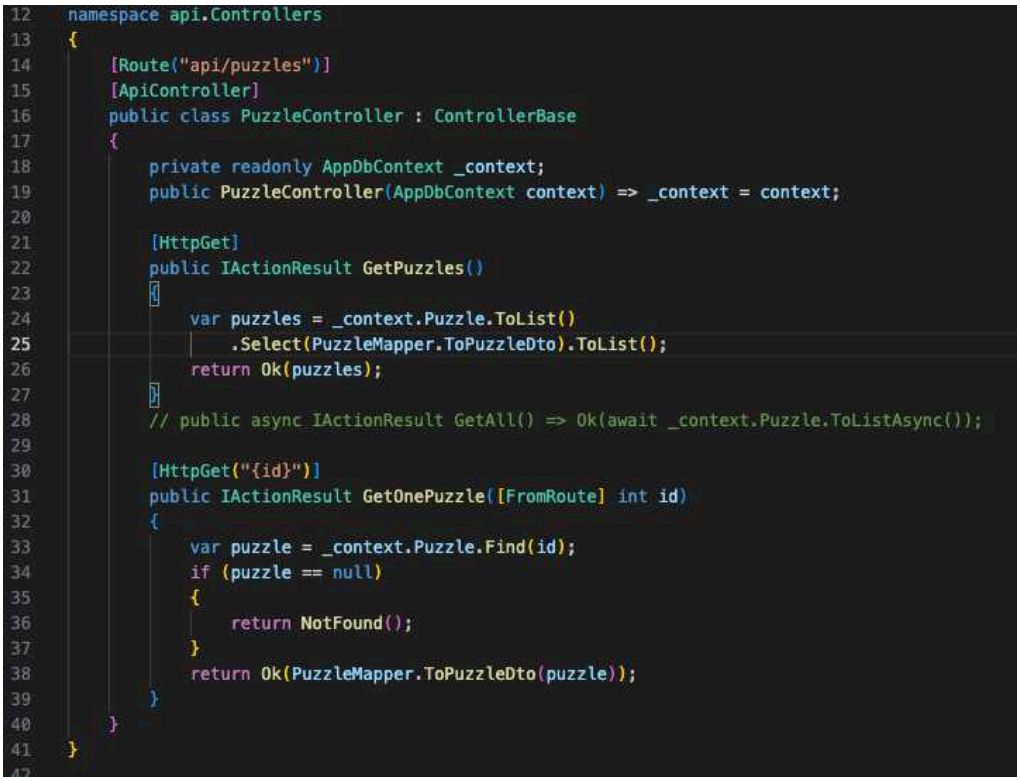


Figure 5.18: Code of PuzzleController

The controller is also configured to handle RESTful API query.

```
return (
  <div className='app-container'>
  <button className="back-button" onClick={() => navigate('/puzzle')}>⬅</button>
  <div className="puzzle-container">
    <h1 className="puzzle-title">{puzzle.artifactName}</h1>

    {solved && (
      <div className="puzzle-solved">
        <h2>🎉 Puzzle Solved!</h2>
        <ul className="puzzle-description">
          {puzzle.description
            ?.split(/(?<=[.?!])\s+/)
            .filter((sentence) => sentence.trim().length > 0)
            .map((sentence, index) => (
              <li key={index}>{sentence.trim()}</li>
            ))}
        </ul>
        <button className="next-puzzle-button" onClick={handleNextPuzzle}>
          {parseInt(id) < totalPuzzles ? 'Next Puzzle' : 'Back to Puzzles'}
        </button>
      </div>
    )}

    <div className="puzzle-board">
      {Array.from({ length: puzzle.imagePaths.length }, (_, i) => i + 1).map((pos) => (
        <div
          key={pos}
          className="drop-zone"
          onDragOver={(e) => e.preventDefault()}
          onDrop={(e) => handleDrop(e, pos.toString())}
        >
          {placedPieces[pos] ? (
            <img
              src={`http://localhost:5249/${pieces.find((p) => p.id === placedPieces[pos])?.imagePath}`}
              alt="piece"
              draggable
              onDragStart={(e) => handleDragStart(e, placedPieces[pos])}
              className="puzzle-piece"
            />
          ) : (
            <span className="drop-zone-text">Drop Here {pos}</span>
          )}
        </div>
      ))}
    </div>

    <div className="pieces-bar">
      {pieces.map((piece) => (
        !Object.values(placedPieces).includes(piece.id) && (
          <img
            key={piece.id}
            src={`http://localhost:5249/${piece.imagePath}`}
            alt="puzzle piece"
            draggable
            onDragStart={(e) => handleDragStart(e, piece.id)}
            className="puzzle-piece"
          />
        )
```

Figure 5.19: Code of Puzzle gameplay page

The frontend using React.js framework is configured to enable the user to freely drag and drop to the correct position.

5.2.4.2 Quiz

Figure 5.20: Quiz selection page

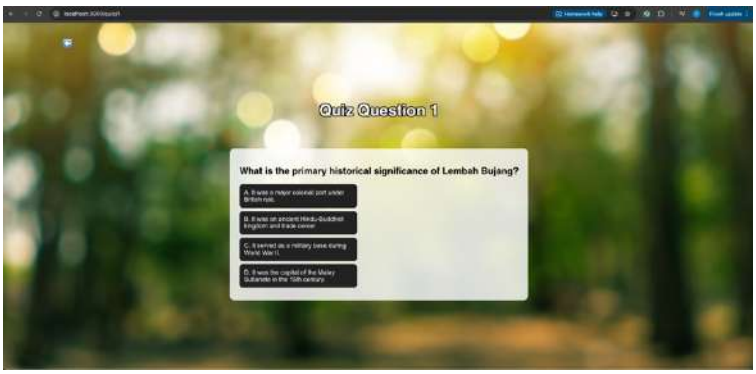


Figure 5.21: Quiz gameplay page

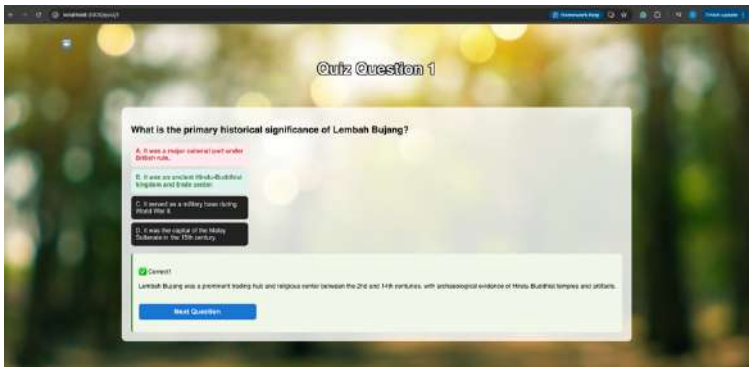


Figure 5.22: Quiz answered page

The user is allow to try and error until the correct selection is chosen. Then, an explanation will be prompt to further tell and educate the user regarding the fact. The user can then click ‘Next Question’ to proceed to the next question.

```
api > Models > Quiz.cs
1   namespace api.Models
2   {
3       public class Quiz
4       {
5           public int Id { get; set; }
6           public string Question { get; set; } = string.Empty;
7           public string OptionA { get; set; } = string.Empty;
8           public string OptionB { get; set; } = string.Empty;
9           public string OptionC { get; set; } = string.Empty;
10          public string OptionD { get; set; } = string.Empty;
11          public string CorrectAnswer { get; set; } = string.Empty;
12          public string Explanation { get; set; } = string.Empty;
13      }
14  }
15
```

Figure 5.23: Code of Quiz model

This is achieved by firstly declaring its model.

```
namespace api.Controllers
{
    [Route("api/quiz")]
    [ApiController]
    public class QuizController : ControllerBase
    {
        private readonly AppDbContext _context;
        public QuizController(AppDbContext context)
        {
            _context = context;
        }
        [HttpGet]
        public IActionResult GetAll()
        {
            var quizzes = _context.Quiz.ToList()
              .Select(QuizMapper.ToQuizDto).ToList();
            return Ok(quizzes);
        }
        [HttpGet("{id}")]
        public IActionResult GetById([FromRoute] int id)
        {
            var quiz = _context.Quiz.Find(id);
            if (quiz == null)
            {
                return NotFound();
            }
            return Ok(QuizMapper.ToQuizDto(quiz));
        }
    }
}
```

Figure 5.24: Code of QuizController

Then the controller is setup to handle RESTful API. Controller is used to communicate with database to fetch data needed.

```
return (
  <div className="app-container">
    <button className="back-button" onClick={() => navigate('/quiz')}>⬅</button>
    <h1>Quiz Question {id}</h1>
    <div className="quiz-box">
      <h2>{question.question}</h2>
      <div className="quiz-options">
        {['A', 'B', 'C', 'D'].map((opt) => (
          <button
            key={opt}
            className={getButtonClass(opt)}
            onClick={() => handleAnswerClick(opt)}
          >
            {opt}. {question[`option${opt}`]}
          </button>
        ))}
      </div>

      {correctSelected && (
        <div className="quiz-feedback">
          <p>✅ Correct!</p>
          <p>{question.explanation}</p>
          <button
            className="next-button"
            onClick={() => {
              const nextId = parseInt(id);
              if (nextId < 10) {
              navigate(`/quiz/${nextId + 1}`);
              } else {
              navigate('/quiz');
              }
            }}
          >
            {parseInt(id) < 10 ? 'Next Question' : 'Back to Menu'}
          </button>
        </div>
      )}
    </div>
  </div>
);
```

Figure 5.25: Code of Quiz display page

The database is passed to frontend when queried, then it is used for question answering.

5.2.5 Storytelling module

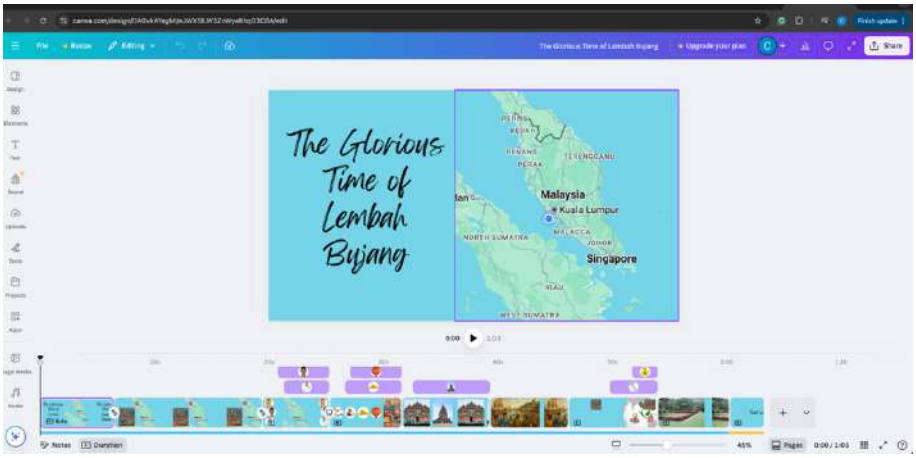


Figure 5.26: Canva animation editing

The storytelling module start with making animation with Canva. After the video is done, it is exported as mp4 as stored in server.

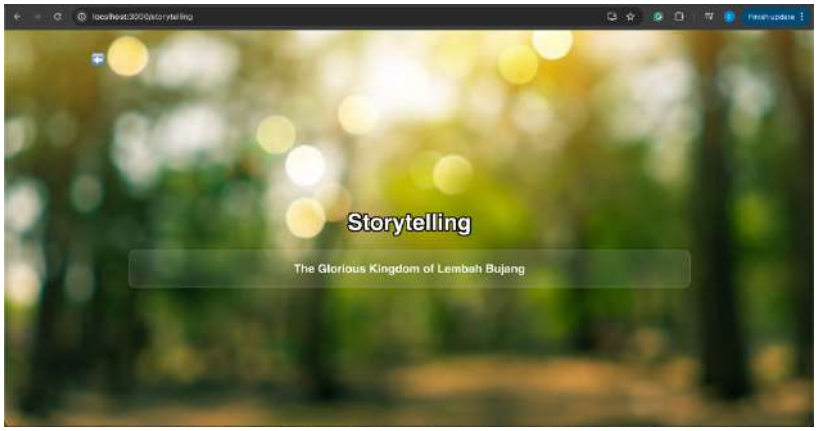


Figure 5.27: Story selection page

```jsx
export default function StoryList() {
  const [stories, setStories] = useState([]);
  const navigate = useNavigate();

  useEffect(() => {
    axios.get('http://localhost:5249/api/story')
      .then(res => setStories(res.data))
      .catch(err => console.error("Error fetching stories:", err));
  }, []);

  return (
    <div className="app-container">
      <button className="back-button" onClick={() => navigate(-1)}>⬅</button>
      <h1>Storytelling</h1>

      <div className="story-list">
        {stories.map(story => (
          <div
            key={story.id}
            className="story-card"
            onClick={() => navigate(`/story/${story.id}`)}
          >
            <h3 className="story-title">{story.title}</h3>
          </div>
        ))}
      </div>
    </div>
  );
}
```

Figure 5.28: Code of story selection page

```csharp
namespace api.Controllers
{
    [ApiController]
    [Route("api/story")]
    public class VideoController : ControllerBase
    {
        private readonly AppDbContext _context;

        public VideoController(AppDbContext context)
        {
            _context = context;
        }

        [HttpGet]
        public IActionResult GetAll()
        {
            var videos = _context.Video.ToList()
                .Select(VideoMapper.ToVideoDto).ToList();
            return Ok(videos);
        }

        [HttpGet("{id}")]
        public IActionResult GetById([FromRoute] int id)
        {
            var video = _context.Video.Find(id);
            if (video == null) return NotFound();
            return Ok(VideoMapper.ToVideoDto(video));
        }
    }
}
```

Figure 5.29: Code of StoryController

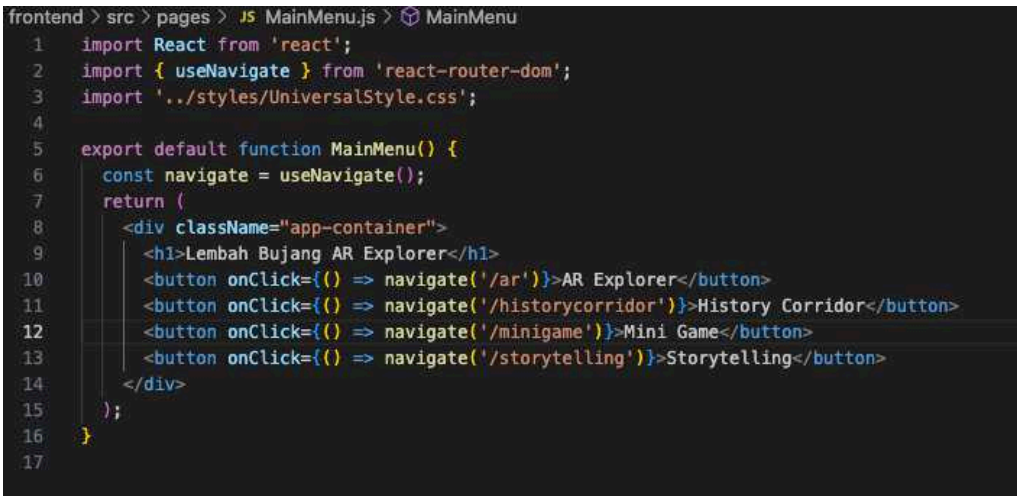
The frontend will use get method to query the backend. The total number of video will be returned as be available for user to select to watch.

Figure 5.30: Story page

When the user choose a video, the user will be brought to the watching page. Then the user can watch and learn from the video.

5.2.6 Main menu

Figure 5.31: Main menu page



```
frontend > src > pages > JS MainMenu.js > MainMenu
1   import React from 'react';
2   import { useNavigate } from 'react-router-dom';
3   import '../styles/UniversalStyle.css';
4
5   export default function MainMenu() {
6     const navigate = useNavigate();
7     return (
8       <div className="app-container">
9         <h1>Lembah Bujang AR Explorer</h1>
10        <button onClick={() => navigate('/ar')}>AR Explorer</button>
11        <button onClick={() => navigate('/historycorridor')}>History Corridor</button>
12        <button onClick={() => navigate('/minigame')}>Mini Game</button>
13        <button onClick={() => navigate('/storytelling')}>Storytelling</button>
14      </div>
15    );
16  }
17
```

Figure 5.32: Code of main menu

The frontend of the website is built using React.JS.

```
14  function App() {
15    return (
16      <BrowserRouter>
17        <Routes>
18          <Route path="/" element={<MainMenu />} />
19          <Route path="/ar" element={<AR />}/>
20          <Route path="/storytelling" element={<StoryList />} />
21          <Route path="/story/:id" element={<StoryDetail />} />
22          <Route path="/minigame" element={<MiniGameMenu />} />
23          <Route path="/puzzle" element={<PuzzleGame />} />
24          <Route path="/puzzle/:id" element={<PuzzleGamePlay />}/>
25          <Route path="/quiz" element={<QuizGame />} />
26          <Route path="/quiz/:id" element={<QuizQuestionDetail />}/>
27          <Route path="/historycorridor" element={<HistoryCorridor />} />
28        </Routes>
29      </BrowserRouter>
30    );
31  }
32
33  export default App;
```

Figure 5.33: Code of route setting

The route is configured so that it fits with the backend configuration.

CHAPTER 6

TESTING, RESULT, AND DISCUSSIONS

6.1 Overview

In this chapter, testing method, testing analysis and results and discussions will be explained. This section presents the evaluation process taken place to ensure the functionality, usability, and reliability of this system. This part of the report highlights how the system is tested, the outcomes of these tests, and the findings in relation to project objectives.

6.2 Method of testing

The method used to conduct the testing is through User Acceptance Testing (UAT) and System Usability Scale (SUS) which are survey that testers need to fill after they try the system. The testers' age are distributed from 18 – 30. A total of 30 testers are involved.

Figure 6.1: Tester 1

Figure 6.2: Tester 2

Figure 6.3: Tester 3

Figure 6.4: Tester 4

6.2.1 User Acceptance Test

User Acceptance Test (UAT) is a testing phase the system is validated by testers in term of meeting business requirements, expectations, and functional needs where users validate if the system meets the business requirements, expectations, and functional needs. It is conducted with the end users or the stakeholders who is going to use the system. In this scenario, the author had found 30 testers to do the testing. This test is carried out at the end of development, after the integration of modules is complete. It is carried out physically, the tester are let to freely explore around the system, after they experience all the features, the questionnaire is given to the tester to fill. According to Nitor (2023), we should carry out UAT because it ensure quality assurance, reduced risks in production, enhance user experience and so on. The process of undergoing this test is predefining test cases or scenarios, and enable the user to freely explore around until they execute predefined test cases, then provide feedback and fill the questionnaire on whether the system behaves correctly.

6.2.2 System Usability Scale

System Usability Scale (SUS), a standardized tool which is questionnaire based, where they measure a system based on usability, learnability, and user satisfaction. According to Soegaard (2025), SUS has become a precious tool in UX design because of how it allows researchers, designers, and others who work on UX. 30 target audience whose age range from 18 to 30 is chosen to act as testers, regardless of technical expertise. The test is carried out together with UAT, the user are given 2 form to fill after the test is done. It is conducted physically after the user explore around the system, the questionnaire is given to tester to fill. Few reasons why we should use SUS is it enhances user-centered evaluation, this is important in current development mode since user are the end-users, their opinion should always be focused. Next, it also provides efficiency and simplicity, enpowers iterative design and supports decision making (Soegaard, 2025). After the user is allowed to explore the system, a survey with 10-item Likert-scale questionnaire is given to the tester. Then, the scores are calculated into a usability index for benchmarking.

6.3 Testing analysis

6.3.1 User Acceptance Test analysis

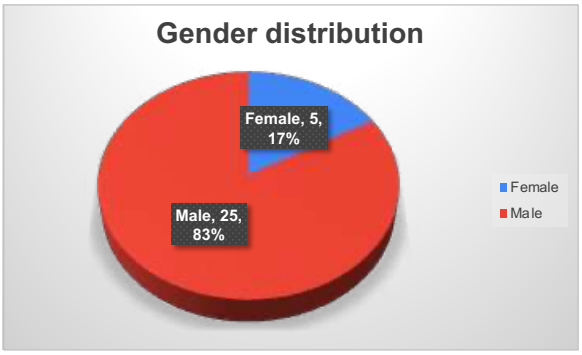


Figure 6.5: Gender distribution

According to Figure 6.5, the gender of 30 testers are 5 females, and 25 males. This suggest that our system work well excluding which gender the testers are. This show the diversity of the system accepting different gender kind of people.

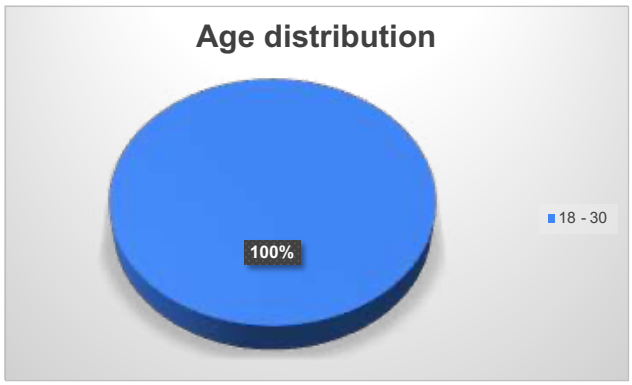


Figure 6.6: Age distribution

Since the system's target audience are 18 – 30, the author choose 30 testers from this age group, this ensure the reliability of the test. This suggest that the system had tested thoroughly by target audience, the feedback and rating are usable.

Figure 6.7: Historical site visitation experience

According to Figure 6.7, there are only 2 person who say they never visit a historical site, 28 of them visited historical site before. This suggest that they would have basic expectation of the system.

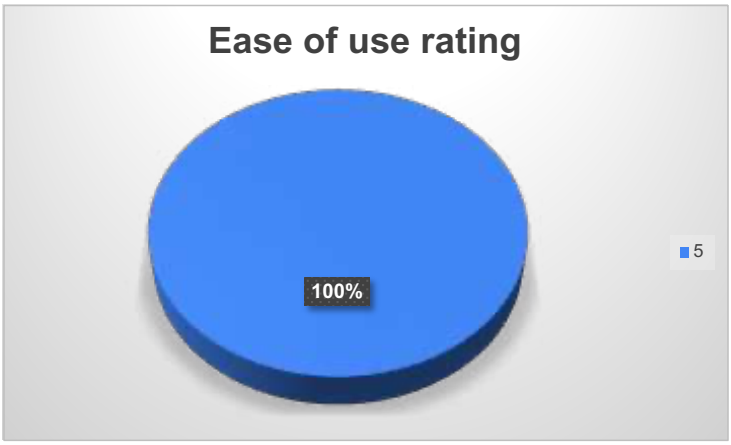


Figure 6.8: Ease of use rating

According to Figure 6.8, all 30 testers think that the system is easy to learn and use. This suggest that the system designed is not complicated and could be handled by them. The design is accepted by the testers and easy to use and learn in their perspective.

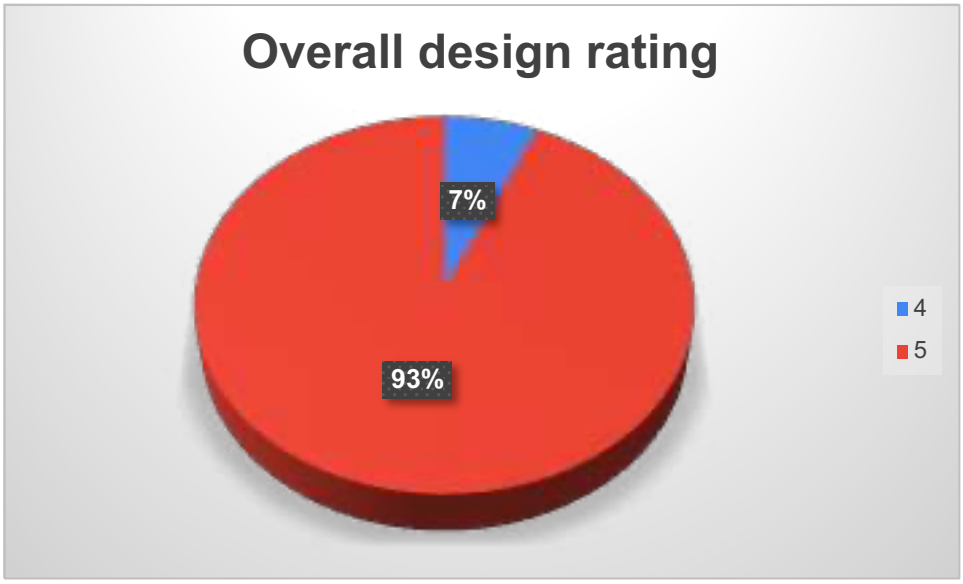


Figure 6.9: Overall design rating

According to Figure 6.9, there are 28 testers rated 5 star to the overall design which is visually appealing and user-friendly. Only 2 testers rated 4 star. This suggests that the overall design is well accepted by the testers, it is not over complicated and suitable to be used among the age group.

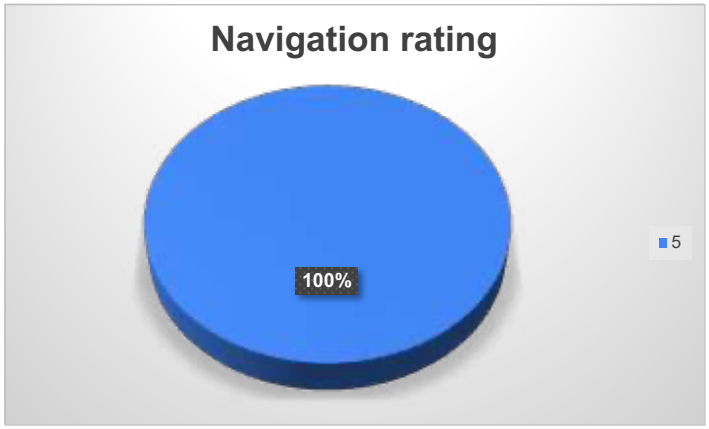


Figure 6.10: Navigation rating

According to Figure 6.10, all 30 testers rated 5 star for the navigation of the system. They think that the navigation of the system is intuitive and easy, this is achieved through simple webpage design and few pages as possible.

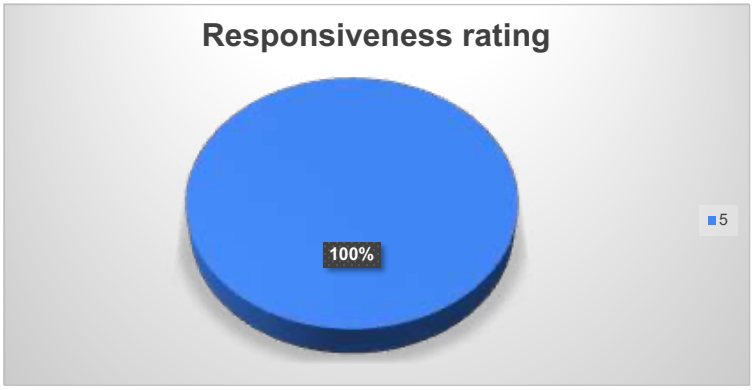


Figure 6.11: Responsiveness rating

According to Figure 6.11, all testers reated 5 star for the responsiveness of the page. The system respond quickly without noticeable delays or errors. This suggests that the system is functioning normally, without any error during testing. This tells that the system is reliable and has good performance.

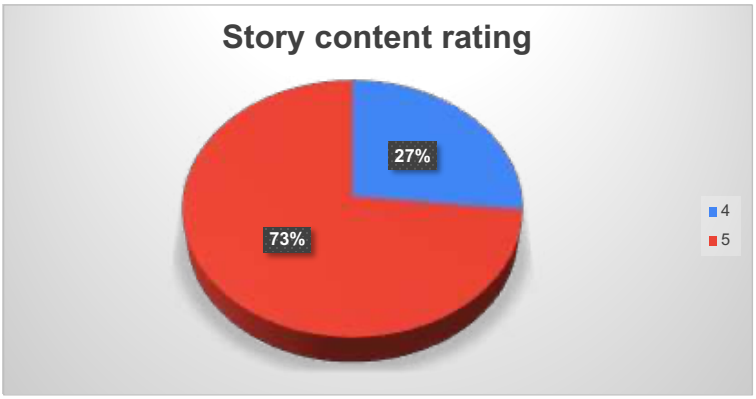


Figure 6.12: Story content rating

According to Figure 6.12, 22 testers rated 5 star for the story content whereas 8 testers think that the story content can only be rated 4 star. Most think that the story content is clear, accurate, and engaging in helping them learn about Lembah Bujang. However, there are needed to be improved.

Figure 6.13: Story video, audio playback rating

According to Figure 6.13, all testers think that the video and audio playback work smoothly without interruptions, hence 5 star are given. This suggest that the stories are told without error and the user experience is not bad. However, the author should continue develop more educational video for more content coverage.

Figure 6.14: Navigation between stories rating

According to Figure 6.14, the navigation between different stories are smooth, the testers had given 5 star in this aspect. This suggest that the user experience is good and satisfied. The implementation of smooth transition is success.

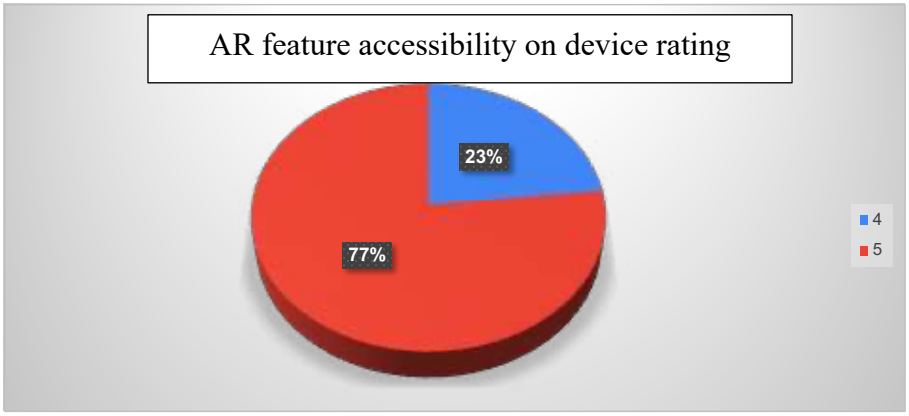


Figure 6.15: AR feature accessibility on device rating

According to Figure 6.15, the AR feature accessibility on testers' device is rated mostly 5 stars, followed by 4 star. All 30 testers are rather satisfied with the accessibility. This is due to the easy installation on their Android device, since the installation can be done using APK. All tester has an Android phone.

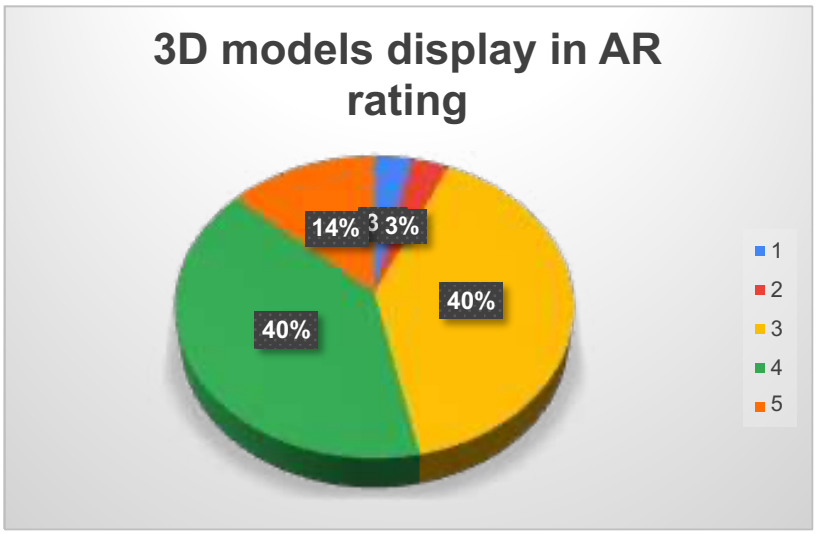


Figure 6.16: 3D models display in AR rating

According to Figure 6.16, the reaction of the testers toward 3D models and animations display when scanning the object has different voice. 40% of them rated 3 stars, 4 stars is rated by 40% of them, 14% of them rated 5 star, and 3% each for 1 star and 2 star.

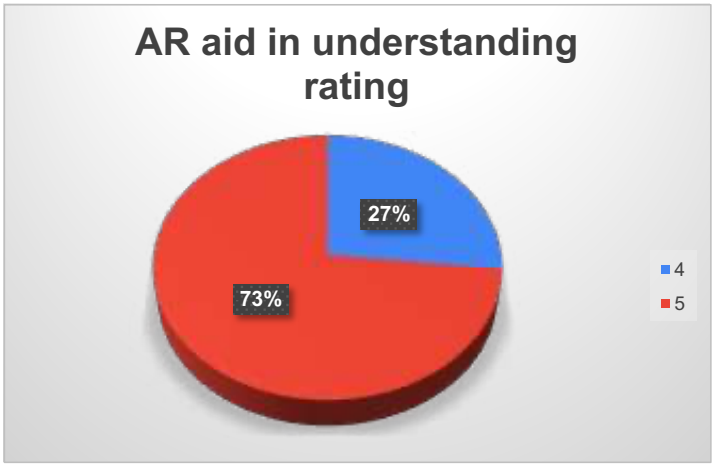


Figure 6.17: AR aid in understanding rating

According to Figure 6.17, the 73% which are 22 of the testers rated 5 star for AR's aid and useful in understanding the site. Whereas 27% which are 8 of them rated 4 star for this section.

Figure 6.18: Timeline sequence rating

According to Figure 6.18, 97% which are 29 of the total testers rated 5 star for the timeline / sequence of historical events presented in a clear and logical order, whereas only 1 person rated 4 star. This suggests that the testers are satisfied with the order of how they are arranged.

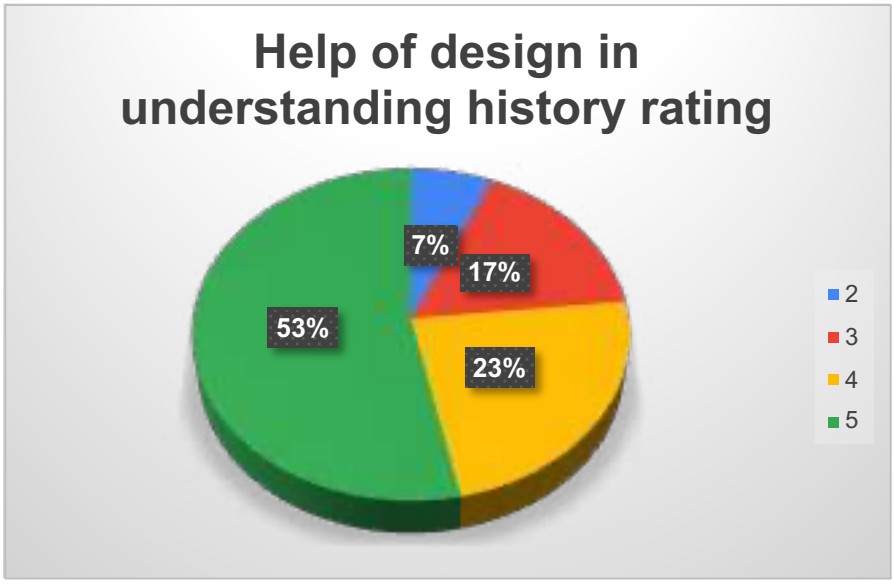


Figure 6.19: Help of design in understanding history rating

According to Figure 6.19, 53% which are 16 of the total testers rated 5 star for the design in helping to understand history better. Whereas 23% of them rated 4 star, 17% rated 3 star, and 7% rated 2 star. This suggest that better improvement is expected for the UI design.

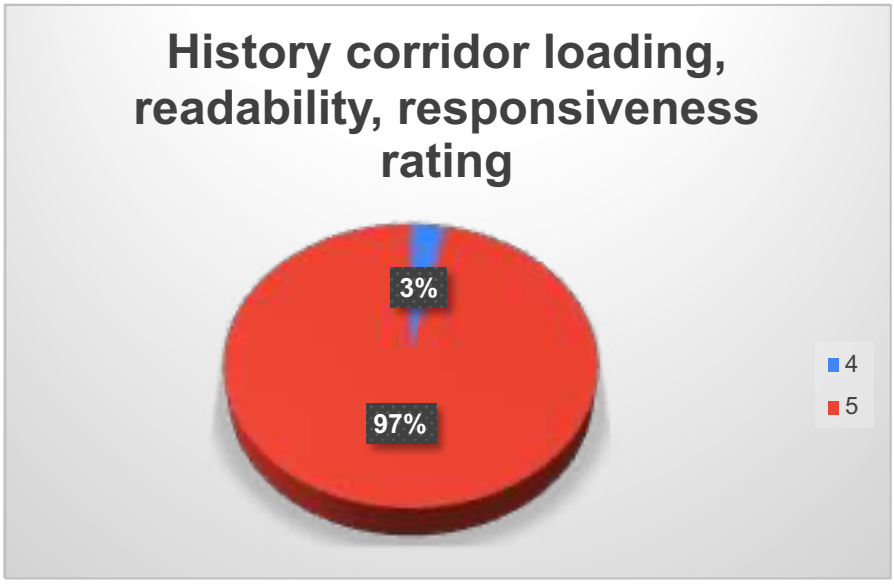


Figure 6.20: History corridor loading, readability, responsiveness rating

According to Figure 6.20, 97% which are 29 of them rated 5 star for history corridor loading, readability, and responsiveness. Whereas 1 tester rated 4 star. This indicate no significant issue during loading and testing.

Figure 6.21: Game function rating

According to Figure 6.21, 83% which are 25 of them rated 5 star and 17% which are 5 of them rated 4 star for game function. The game function such as drag & drop puzzle pieces, quiz answering and scoring function normally during testing.

Figure 6.22: Game enhance learning experience rating

According to Figure 6.22, 80% which are 24 of testers rated 5 star, 17% which are 5 of them rated 4 star, 3% which are 1 of them rated 3 star for game make their learning experience more interactive and enjoyable. The average rating is 4.77.

Figure 6.23: Game instruction rating

According to Figure 6.23, 87% which are 26 of total testers rated 5 star whereas 13% which are 4 of them rated 4 star for the clearness and ease to follow the game instruction. This suggest that the users are rather satisfied with the instruction of the game.

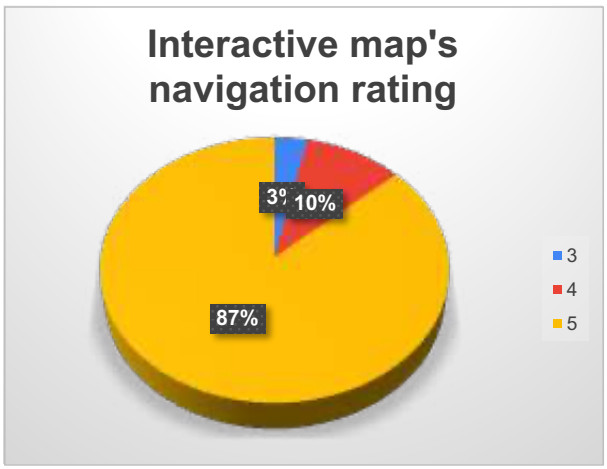


Figure 6.24: Interactive map's navigation rating

According to Figure 6.24, 87% which are 26 of the total testers rated 5 star, 10% which are 3 of them rated 4 star, and 3% which are 1 of them rated 3 star in the navigation of interactive map rating. Their opinions are it is easy to navigate and explore the map of historical sites.

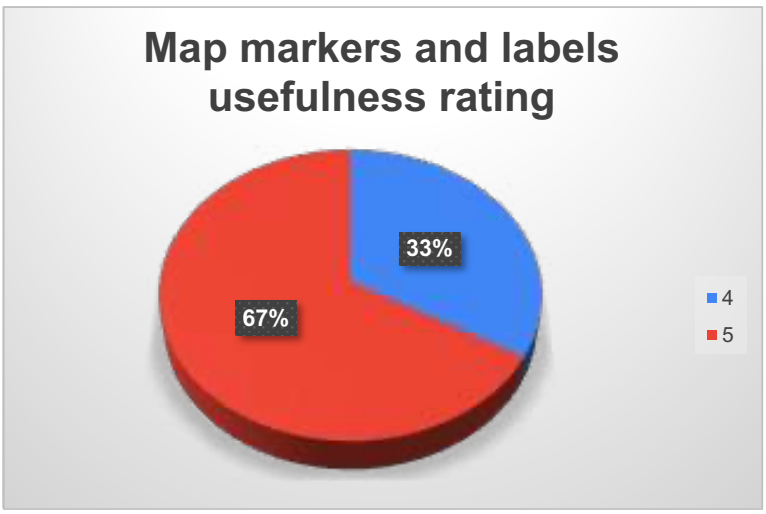


Figure 6.25: Map markers and labels usefulness rating

According to Figure 6.25, 67% which are 20 of them rated 5 star, whereas 33% which are 10 of them rated 4 star in the usefulness of map markers and labels in providing useful and accurate information.

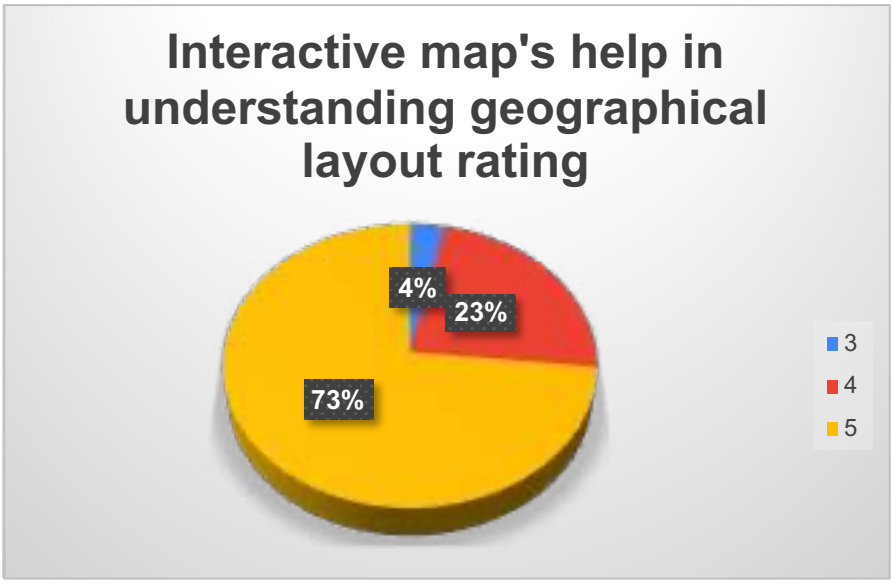


Figure 6.26: Interactive map's help in understanding geographical layout rating

According to Figure 6.26, 73% which are 22 of the total testers rated 5 stars, 23% which are 7 of them rated 4 star, and 4% which are 1 individual rated 3 star on the interactive map's help in understanding geographical layout.

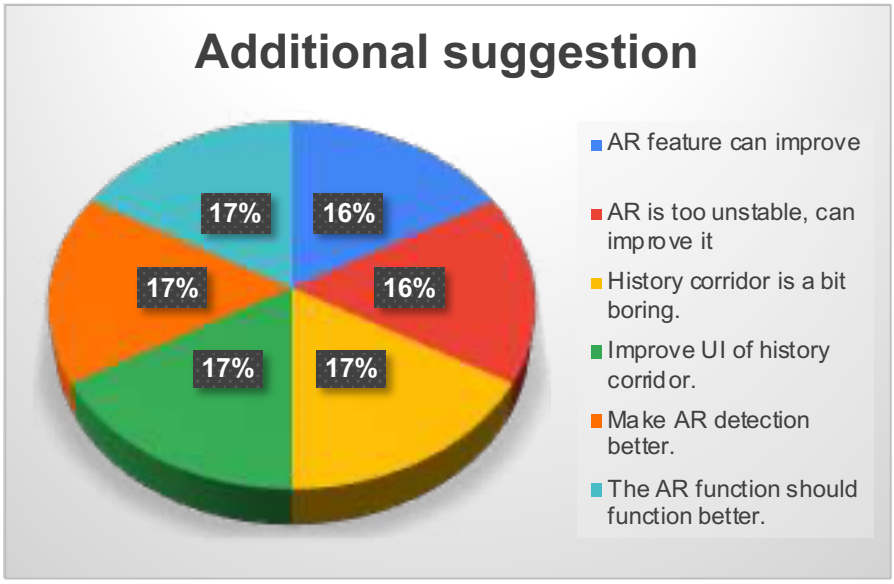


Figure 6.27: Additional suggestion

According to Figure 6.27, few additional suggestion is given. Most focus on improving AR features, where some address the oversimplified history corridor. More improvement should be done especially in the stability of AR image targets.

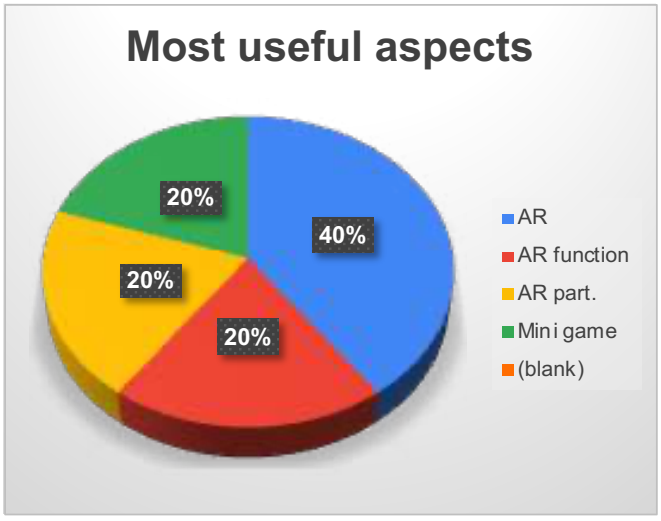


Figure 6.28: Most useful aspects

According to Figure 6.28, the most useful aspect are AR feature. This might due to the fact that AR is not popularise among the public, it is a new experience for them. Some stated mini game, this might due to they prefer to learn in a more interactive way.

6.3.2 System Usability Scale test analysis

In SUS, there are 10 questions to be answered. They are included in Appendix C. The testers are allowed to give feedback and rate based on their using experience. A total of 30 testers had fill the SUS survey.

	A	B	C	D	E	F	G	H	I	J	K	L
1	1. I think that I would like to use this website/system for booking/ reservation related matter.	2. I found the website/system unnecessarily complex.	3. I thought the website/system was easy to use	4. I think that I would need the support of a technical person to be able to use this website/system.	5. I found this website/system was easily moved through without a lot of backtracking or data re-entry.	6. I thought there was too much inconsistency in this website/system.	7. I would imagine that most people would learn to use this website/system very quickly.	8. I found the system/website very awkward to use.	9. I felt very confident using the system/website.	10. I needed to learn a lot of things before I could get going with this website/system.	Sum * 2.5	Sum
2	4	1	5	2	5	1	5	1	5	1	95	38
3	5	1	5	2	5	2	5	2	4	1	90	36
4	2	1	5	4	4	1	4	2	5	3	72.5	29
5	5	1	5	1	5	1	5	1	5	1	100	40
6	3	2	5	3	5	1	5	1	5	1	87.5	35
7	5	1	5	1	5	1	5	1	4	1	97.5	39
8	4	1	5	2	5	1	5	1	5	1	95	38
9	4	2	4	2	4	2	4	2	4	2	75	30
10	4	1	5	2	5	3	4	2	4	2	80	32
11	3	1	4	4	5	1	4	1	4	4	72.5	29
12	2	1	4	3	5	1	4	1	3	3	72.5	29
13	3	2	4	5	5	2	4	2	3	3	62.5	25
14	3	1	4	3	5	2	3	2	3	2	70	28
15	3	2	4	4	5	2	4	2	3	3	65	26

Figure 6.29: SUS result part 1

16	4	1	5	2	5	3	5	2	4	3	80	32
17	4	1	5	2	5	1	4	2	4	2	85	34
18	3	1	5	3	5	2	3	1	3	3	72.5	29
19	2	2	4	3	5	2	4	2	3	2	67.5	27
20	3	1	4	5	5	2	4	3	3	1	67.5	27
21	3	2	4	3	5	2	4	2	4	2	72.5	29
22	2	1	5	4	5	2	5	2	5	2	77.5	31
23	4	1	5	1	5	1	5	1	5	1	97.5	39
24	4	1	5	3	5	2	4	3	4	3	75	30
25	5	1	5	1	5	1	5	1	5	1	100	40
26	3	2	5	3	5	1	5	1	5	1	87.5	35
27	4	1	5	2	5	3	5	2	4	3	80	32
28	3	1	5	3	5	1	4	2	4	2	80	32
29	4	1	4	2	5	2	4	1	4	1	85	34
30	4	1	5	2	5	1	5	1	4	2	90	36
31	3	1	5	3	5	2	4	2	4	2	77.5	31
32											77.9347826	

Figure 6.30: SUS result part 2

Figure above show the result of SUS, where to most right and 2nd most right column indicate the result after applying a formula.

```
=((A2-1)+(5-B2)+(C2-1)+(5-D2)+(E2-1)+(5-F2)+(G2-1)+(5-H2)+(I2-1)+(5-J2))*2.5
```

Figure 6.31: SUS score calculation formula

Figure above indicate the sample formula implemented. The odd number question response are subtracted by 1, whereas even number question, we subtract the user response from 5. This scales all value from 0 – 4. Then we sum up the converted responses and multiple that total by 2.5. Then, all responses are sum up and divided by total number of testers.

6.4 Results and discussions

6.4.1 UAT

The UAT was conducted to evaluate the overall user experience, functionality, and usability of this immersive interaction system for Lembah Bujang heritage. The questionnaire was structured into several modules, they are system usability, storytelling module, AR module, history corridor module, mini game module and interactive map module.

As a result, we can see system usability achieve the highest rating with a mean score of 4.98/5.0, showing that the testers found the platform responsive, visually appealing and easy to use. The storytelling module followed closely with a mean of 4.91/5.0, indicating that the historical narratives are clear, effective and engaging in enhancing learning. Mini game module achieved a mean of 4.82/5.0, suggesting that interactive games were contributing and well-liked in giving vibing learning experiences. The History Corridor Module (M = 4.72/5) and Interactive Map Module (M = 4.73/5) received favorable ratings as well, emphasizing the usefulness of the navigational aids and the rational presentation of historical events. The AR Module scored higher than normal, although with a somewhat lower mean of 4.36/5. This indicates that users had some performance problems even though they valued AR's contribution to visualization and engagement. Recurring recommendations for enhancing AR detection stability and interaction smoothness were found in open-ended responses. It's interesting to note that customers regularly cited the AR feature as the most helpful feature of the system, despite its lower average score, highlighting how valuable they thought it was.

UAT results confirm that the system had met its functional and usability requirements, with overall acceptance from end users. The high usability score suggests that design decisions in interface layout, navigation, and

responsiveness reduced user irritation and allowed for seamless engagement. The high ratings for storytelling and mini-games highlight the value of mixing narrative-driven content with gamified learning to increase engagement and knowledge.

However, the slightly lower performance of AR module highlights area for refinement. Technical issues such as AR marker instability, rendering performance may have affected user experience. The author should focus on the 3D model of ruin which has lower high-contrast feature. By modifying the 3D model, the feature which could be used by Vuforia would increase and hence the detection would be much easier. The author should use better texture, hence produce better result. Since AR was also identified as the most precious feature by many testers, addressing these challenges could boost overall satisfaction and system usability and credibility significantly.

Overall, the UAT demonstrates that the system had achieved user acceptance. The feedback identifies specific enhancement opportunities, particularly in AR optimization, which will increase the system's ability to combine heritage learning with cutting-edge interactive technology.

6.4.2 SUS

Table 6.1: System Usability Scale Acceptability Score

SUS Score	Percentile Range	Grade	Rank
84.1 – 100	96 – 100	A+	Best imaginable
80.8 – 84.0	90 – 95	A	
78.9 – 80.7	85 – 89	A-	
77.2 – 78.8	80 – 84	B+	Excellent
74.1 – 77.1	70 – 79	B	
72.6 – 74.0	65 – 69	B-	
71.1 – 72.5	60 – 64	C+	Good
65.0 – 71.0	41 – 59	C	
62.7 – 64.9	35 – 40	C-	
51.7 – 62.6	15 – 34	D	Okay
0 – 51.6	0 -14	F	Poor

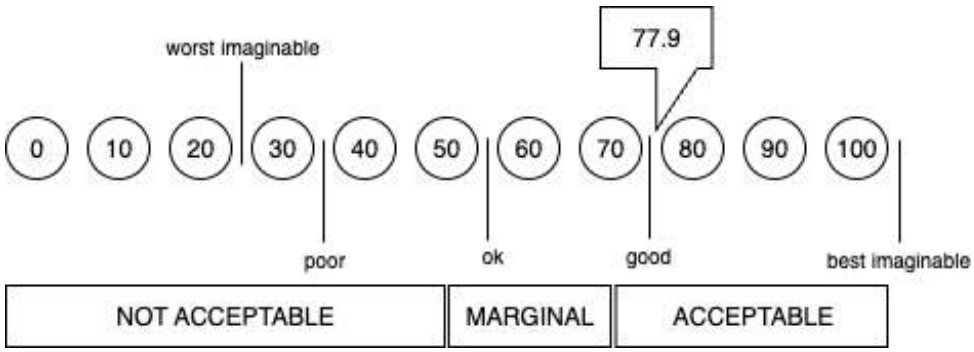


Figure 6.32: SUS Acceptability Score

As result, the average SUS score after calculation is 77.9, which is just right in the range of 'excellent' benchmark according to Bellio (2025). This indicates that the system's usability is considered good since it cross the commonly accepted benchmark of 68 (Karampelas, 2017). The findings suggest that the testers generally perceived the system as easy to use, supportive, and efficient for their tasks. The high average SUS score reflects that most users are capable to interact and navigate with the system without significant difficulties, indicating a positive user experience.

However, the range of scores also shows some inconsistencies. While few testers rated highly of the system (≥90), some rated lowly (≤70), the lowest can go to 62.5. This indicates that certain testers may have faced challenges such as steep learning curves, requiring additional technical support or unclear navigation. This disparity suggests that while the system meets usability expectations for the majority, there is still space for improvements to enhance user experience.

In particular, enhanced onboarding materials, clearer instructions, or simplified interface elements can help testers who scored the system lower. Addressing these problems help improving overall system usabilily rating, at the same time raising the lower-end scores.

Overall, the SUS results demonstrate that most testers had found it satisfactory and effective, which indicate the system has achieved a strong level of usability. The author can continue refining the system based on user feedback which could push the system's usability into the 'best imaginable' category and ensure consistency in positive experiences.

CHAPTER 7

CONCLUSION

7.1 Overview

In conclusion, most of the objectives are met in this project. Problem statements are also satisfied.

7.2 Research findings

The first objective was to investigate the potential usage of AR and digital media technologies for digital heritage preservation at Lembah Bujang. This objective is achieved based on the discussion from UAT and SUS results. The system had demonstrated its AR overlay features and 3D reconstructions could successfully preserve and present the archaeological site in a way that enhances knowledge retention and engagement. The problem statement of stating lack of AR functionalities is fully addressed. Apart from that, Users rated the storytelling, mini game, and usability aspects highly, mean score of 4.9, confirming that AR and digital media improve accessibility, user satisfaction and contextual storytelling, addressing the identified problem of limited accessibility features in existing platforms.

The second objective of to develop an interactive AR-aided software through an exploratory approach is partially achieved. User reception of the produced software, which included interactive modules like augmented reality, history corridors, and mini-games, was largely favorable. The AR module did, however, receive a somewhat lower score (M = 4.36), indicating that although the AR functionalities were useful and acknowledged as the most valuable feature, stability and accessibility issues persisted. The problem statement about the absence of strong AR features in current systems is reflected in this. Even though consumers found the unique features appealing, the exploratory AR technique requires improvement in detection accuracy, device compatibility, and interaction design.

The third objective is to evaluate the effectiveness of the AR based software application in supporting the heritage preservation efforts especially to support for archaeological site visualization. This is also partially achieved.

Strong acceptability of the system as an instructional tool was confirmed by UAT evaluation, particularly through mini-games and narrative, which improved user engagement and learning. Though AR visualization made a beneficial contribution, its smooth integration into preservation and visualization duties was hindered by technical constraints. Therefore, even though the system effectively facilitated accessibility and heritage education, more iterations are needed to maximize AR characteristics for more precise, reliable, and inclusive archaeological representation.

7.3 Problem faced

7.3.1 Steep learning curve of Blender and Unity

The steep learning curve involved in becoming proficient in Blender and Unity was one of the biggest problem the project faced. Although both systems are quite strong and flexible, learning them takes a lot of time and work. Particularly with Blender, grasping its many features, from modeling and texturing to rendering required much patience. In contrast, Unity added another level of complexity by incorporating scripting, scene design, and integration with third-party tools like Vuforia. At first, the author found it difficult to comprehend the interface, features, and workflows because they had no prior familiarity with these tools. Numerous hours of trial and error, self-education through tutorials, and perseverance in problem-solving were necessary for this. Despite its challenges, the approach steadily increased the author's technical expertise and fortitude.

7.3.2 Difficulty in producing high star Vuforia image target

The difficulty of creating excellent Vuforia image targets was another issue encountered during the project. How well an image can be tracked in augmented reality is reflected in Vuforia's rating system, which uses a star scale to assess image targets. Because they lacked enough contrast, clear patterns, or textural elements, many of the first selections received poor star ratings. Because of this, the tracking was erratic and frequently resulted in the AR information flickering or going away. It took careful image selection and occasionally even pre-processing to improve contrast and detail in order to reach higher-star image

targets. Because the stability and usability of the AR application were directly impacted by the quality of the picture targets, this was a time-consuming operation.

7.3.3 Limited hardware performance and resource constraints

During development and testing, hardware and resource constraints were another likely issue that arose. It is resource-intensive to run Blender, Unity, and Android emulators all at once; significant CPU, GPU, and memory power are needed. This frequently led to system slowdowns, lengthy build times, or crashes on computers with middling specs. These limitations sometime decrease and slow down the development process, as the author need to constantly adjust workflows, optimize assets. Such constraints highlighted the vitality of having efficient resource management and optimization in real-world development.

7.4 Knowledge gained

7.4.1 The usability and function of development tools

One of the most valuable knowledge gained by the author through this project is the practical usability and operation of Blender. Before enrolling into this project, the author had no prior experience in 3D modeling. This project provided a precious opportunity to experiment and explore freely with 3D design. In doing so, the author realized that mastering Blender requires not only understanding technically but also a lot of patience, dedication, and resilience, as the learning curve can be steep and time-consuming. Apart from that, the author also learned how to integrate Vuforia with Unity to enable augmented reality (AR) features. This process highlights the importance of image quality in AR recognition, since this is how image targets are most effective when they contain high color contrast and a degree of texture or roughness. These insights not only enhanced the author’s technical skills but also fostered a deeper appreciation of how digital platforms and tools work together to bring immersive experiences to life.

7.4.2 The process of exploratory learning

Through learning the concept of exploratory learning, the author had gained a new outlook on education and information acquisition. The Malaysian educational system which is more traditional, teacher-centered approach where pupils are spoon-fed knowledge in an organized and consistent way is challenged in exploratory learning. By giving them the ability to investigate several modules in any order they like, it enables students to take charge of their own education. This adaptability increases interest, reduces boredom, and significantly boosts engagement and retention. The author's first experience with this strategy has opened his eyes and given him important insight into how interactive and learner-driven approaches could be significantly more effective in generating interest and passion compared with cenvention method, especially in training or educational settings.

7.4.3 Integrating frontend and backend of different language

The integration of frontend and backend systems created using completely different programming languages and frameworks was another important knowledge gained from this project. React.js is used to build the frontend, and ASP.NET in C# is used to develop the backend. The author managed to develop a in-depth understanding of how various technologies interact with one another through APIs and data exchange methods in order to bridge these two quite diverse settings. In addition to enhancing the author's technical problem-solving abilities, this integration process highlighted how crucial adaptability is while operating in different settings. Modern software development requires the ability to align and synchronize many languages and platforms, and this project provided the author with precious hands-on expertise in ensuring smooth interoperability between different technologies.

7.5 Limitations

7.5.1 Insufficient image tracking feature

One of the biggest limitations is the instability in the image tracking functionality. The tracking often has trouble staying consistent, especially when there are no enough distinctive or recognizable elements in the reference photos

being used. The stability and accuracy of the augmented reality (AR) overlay are often diminished by images that lack identifiable patterns, sharp contrast, ,or distinct textures., The virtual content may appear to wander, misalign, or even vanish even when the camera had kept a proper lock on the picture target. This restriction emphasizes how crucial it is to carefully plan or choose appropriate target images in order to ensure more stable and seamless AR functionality.

7.5.2 Device compatibility

The application's limited device compatibility is yet another important drawback. The system can only be installed and used by those who have Android devices because it is currently only available as an Android application package (APK). The application is inaccessible to iOS users, which puts a significant percentage of the target audience at a disadvantage. This restriction not only limits the system's broad reach but also has an impact on inclusivity, especially in situations when the user base is diverse and comprises owners of both iOS and Android devices. Cross-platform development or extra work to package the application for multiple operating systems would be necessary to overcome this limitation.

7.5.3 Tendency effects from environmental changes

Another limitation is tendency effects from environmental changes. Environmental elements, such as lighting, have a serious impact on the image tracking feature's performance. A detrimental influence on the system's capacity to identify and track pictures can be caused by changes in ambient brightness, shadows, or glare. For example, inadequate illumination might make it difficult to see important feature of the target image, while too much light or surfaces with reflections can cause tracking issues since it skew the camera's input and. The application's resilience is diminished by this reliance on environmental stability, which may also restrict its applicability in real-world situations where lighting is not always controlled. This limitation highlights the necessity of improved algorithms or hardware support to increase resilience in a range of environmental circumstances.

7.6 Future enhancements

7.6.1 Adapt AR functionalities in other module

The merging of augmented reality (AR) elements into other modules is one key aspect for future enhancement. For instance, augmented reality adaptation into mini-game module can significantly improve it. While quizzes might leverage augmented reality (AR) components to provide questions and answers in a more interesting, immersive style, puzzle game parts might be displayed in 3D space, enabling more dynamic user interaction. Similarly, the History Corridor module can enhance the user experience significantly by displaying 3D models of artifacts, buildings, or cultural objects from various historical eras with the aid of augmented reality. This would increase user engagement and retention and create a more memorable educational experience by enabling users to observe and interact with historical things in a lifelike manner in addition to reading about them.

7.6.2 Provide installation for iOS users

Since the application is only available as APK, they are only accessible to Android users. To extend compatibility to iOS devices, future enhancement could be developing an installation package for Apple customers via the App Store. Support for iOS would ensure inclusivity and increase the application's user base, increasing its adaptability and appeal in a variety of contexts, including educational institutions, museums, and public displays. A higher scalability and sustainability could be achieved by the system by implementing cross-platform development frameworks or by allowing native versions for both iOS and Android. This ensure that consumers from other ecosystems can equally access the experience.

7.6.3 Use more detailed and higher contrast images for AR tracking

Using better-quality image targets to increase the accuracy and dependability of AR tracking is another future enhancement to be considered. The limitations is shown when photos don't have enough contrast, detail, or distinguishing characteristics. In the future, AR markers might be more precisely chosen or custom created images. Rich textures, , high contrast and distinctive patterns

images can significantly enhance the system's ability to sustain steady tracking even under less ideal circumstances. Moreover, applying image preprocessing methods such as improving contrast, modifying brightness, or lowering background noise, could improve recognition drastically. A more smooth and reliable augmented reality experience would result from this, lowering interruptions and raising user satisfaction levels all around.

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APPENDICES

Appendix A: Survey questionnaire questions

The full survey questionnaire used for user requirement gathering is attached below in its original format as designed in Google Forms.

Survey on User Perception and Expectations for an Augmented Reality-Based Heritage Learning Platform

Hi, I'm **Chow Chong Bao**, a final-year Software Engineering student at **Universiti Tunku Abdul Rahman (UTAR)**. For my Final Year Project, I am working on an Augmented Reality-Based Heritage Learning Platform.

This questionnaire aims to collect your valuable insights on the challenges and preferences in learning about historical and cultural heritage sites. Your feedback will contribute to the development of a web-based educational platform featuring **Augmented Reality (AR)**, **storytelling**, **interactive maps**, **history corridors**, and **mini-games** to create a more engaging and effective learning experience. Whether you're a student, educator, or heritage enthusiast, your input is important to help us shape a meaningful and user-friendly application. All responses will be kept confidential and used solely for research purposes.

The survey takes about **5–10 minutes** to complete. Thank you for your time and support!

* Indicates required question

1. Email: *

Section A: User demographic data

2. 1. What is your age group? *

Mark only one oval.

- ◯ Under 18 years old
- ◯ 18 - 30 years old
- ◯ 31 - 55 years old
- ◯ Above 55 years old

3. 2. What is your gender? *

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Prefer not to say
- ◯ Other: _____

4. 3. What is your curent occupation? *

Mark only one oval.

- ◯ Student
- ◯ Educator / Teacher
- ◯ Working Professional (e.g., engineer, marketer, designer)
- ◯ Government Employee
- ◯ Retired
- ◯ Unemployed
- ◯ Other: _____

5. 4. Have you visited a historical site before? *

Mark only one oval.

- ◯ Yes
- ◯ No

Section B: Difficulties in learning a historical site or heritage

6. 1. What challenges do you face when learning about history? (Check all that apply) *

Check all that apply.

- [ ] Difficulty understanding historical context
- [ ] Lack of engagement / content is boring
- [ ] Hard to visualize past events and places
- [ ] Too much text, not enough interactive content
- [ ] Lack of reliable or accessible resources
- [ ] Other: _____

7. 2. What learning method do you prefer for historical topics? *

Check all that apply.

- [ ] Reading articles and book
- [ ] Watching videos or documentaries
- [ ] Interactive experiences (e.g. AR, VR, simulations)
- [ ] Attending guided tours and lectures
- [ ] Other: _____

8. 3. Do you find traditional methods of learning (e.g., textbooks, static images) effective for understanding historical sites? *

Mark only one oval.

- ◯ Very effective
- ◯ Somewhat effective
- ◯ Neutral
- ◯ Not very effective
- ◯ Not effective at all

9. 4. What would make learning about historical sites more engaging for you? (Check all that apply) *

Check all that apply.

- [ ] Interactive maps and timelines
- [ ] Augmented reality reconstructions
- [ ] Audio narrations or guided tours
- [ ] Gamification (e.g., quizzes, challenges
- [ ] Other: _____

Section C: Exposure on the technologies in learning

10. 1. Which technologies have you used for learning about historical or cultural sites? (Select all that apply) *

Check all that apply.

- [ ] Virtual Reality (VR)
- [ ] Augmented Reality (AR)
- [ ] 360-degree videos or images
- [ ] Interactive websites or apps
- [ ] None of the above
- [ ] Other: _____

11. 2. How familiar are you with Augmented Reality (AR) technology? *

Mark only one oval.

- ◯ Very familiar (I use it regularly)
- ◯ Somewhat familiar (I have used it a few times)
- ◯ Not very familiar (I have heard of it but never used it)
- ◯ Not familiar at all

12. 3. What devices do you own that could support AR experiences? *

Mark only one oval.

- ◯ Smartphone (iOS/Android)
- ◯ Tablet
- ◯ AR glasses (e.g., Microsoft HoloLens, Google Glass)
- ◯ None

13. 4. How likely are you to use an AR-based website for learning about historical sites? *

Mark only one oval.

- ◯ Very likely
- ◯ Somewhat likely
- ◯ Neutral
- ◯ Not very likely
- ◯ Not likely at all

14. 5. What features would you expect in a website or app for exploring a historical site? (Select all that apply) *

Check all that apply.

- ☐ 3D reconstructions of historical structures
- ☐ Interactive maps with key locations
- ☐ Audio narrations or guided tours
- ☐ Historical timelines and context
- ☐ Gamification elements (e.g., quizzes, scavenger hunts)
- ☐ Other (please specify)

Section D: Users Expectation for each modules

There will be 5 part in this section, your patience in completing this form is much appreciated.
Thank you !!! 🙏🙏🙏

Part 1: Storytelling

15. 1. How engaging do you think storytelling experience will help in learning? *

Mark only one oval.

- ◯ Very engaging
- ◯ Somewhat engaging
- ◯ Neutral
- ◯ Not very engaging
- ◯ Not engaging

16. 2. Will the storytelling help you understand the historical significance of the site? *

Mark only one oval.

- ◯ Yes
- ◯ No

17. 3. How important is it for the storytelling module to include multimedia elements (e.g., images, videos, animations)? *

Mark only one oval.

- ◯ Very important
- ◯ Somewhat important
- ◯ Neutral
- ◯ Not very important
- ◯ Not important at all

18. 3. Would you like the storytelling to include personal stories or anecdotes from historical figures? *

Mark only one oval.

- Yes
- No
- Neutral

19. 4. Would you prefer short storytelling snippets or a long immersive narrative? *

Mark only one oval.

- Short snippets
- Long narrative
- Both options

20. 5. Do you want the ability to personalize the storytelling experience (e.g., choose character perspectives, adjust pace)? *

Mark only one oval.

- Yes
- No

Section D: Users Expectation for each modules

There will be 5 part in this section, your patience in completing this form is much appreciated.
Thank you !!! 🙏🙏🙏

Part 2: AR

AR (Augmented Reality) adds digital elements (like images, sounds, or 3D objects) to the real world using devices like smartphones or AR glasses. It blends virtual content with your real environment in real time. Pokemon Go is one of AR application.

21. 1. How interested are you in using AR to visualize historical structures or artifacts? *

Mark only one oval.

- ◯ Very interested
- ◯ Somewhat interested
- ◯ Neutral
- ◯ Not very interested
- ◯ Not interested at all

22. 2. Would you like the AR module to showcase different historical periods (e.g., how the site evolved over time)?

Mark only one oval.

- ◯ Yes, very important
- ◯ Somewhat important
- ◯ Neutral
- ◯ Not very important

23. 3. How important is it for the AR module to include educational content (e.g., historical facts, cultural context)? *

Mark only one oval.

- ◯ Very important
- ◯ Somewhat important
- ◯ Neutral
- ◯ Not very important
- ◯ Not important at all

24. What other additional feature do you expect in AR module?

Section D: Users Expectation for each modules

There will be 5 part in this section, your patience in completing this form is much appreciated.
Thank you !!! 🙏🙏🙏

Part 3: Interactive Map

25. 1. How important is it for the website to include an interactive map for navigation? *

Mark only one oval.

- Very important
- Somewhat important
- Neutral
- Not very important
- Not important at all

26. 2. How important is it for the website to show the places you have visited on interactive map? *

Mark only one oval.

- Very important
- Somewhat important
- Neutral
- Not very important
- Not important at all

27. 3. Should the map provide real-time user location tracking? *

Mark only one oval.

- ◯ Yes
- ◯ No

28. What other additional feature do you expect in interactive map module?

Section D: Users Expectation for each modules

There will be 5 part in this section, your patience in completing this form is much appreciated.
Thank you !!! 🙏🙏🙏

Part 4: History Corridor

The History Corridor is an interactive digital feature that showcases the evolution of a historical site over time. It allows users to explore different time periods through visual comparisons (e.g., past vs. present), animations, and informative pop-ups. By moving through timelines or tapping on different eras, users can see how the site developed and understand its historical significance in an engaging and immersive way.

29. 1. How important is it for the website to include the history corridor that showcase the evolution of the site over time? *

Mark only one oval.

- ◯ Very important
- ◯ Somewhat important
- ◯ Neutral
- ◯ Not very important
- ◯ Not important at all

30. 2. How important is it for the history corridor to include visual comparisons (e.g., past vs. present)? *

Mark only one oval.

- ◯ Very important
- ◯ Somewhat important
- ◯ Neutral
- ◯ Not very important
- ◯ Not important at all

31. 3. Should the History Corridor allow interactive exploration (e.g., tap to reveal facts, move through different centuries)? *

Mark only one oval.

- ◯ Yes
- ◯ No

32. 4. What other additional feature do you expect in history corridor module?

Section D: Users Expectation for each modules

There will be 5 part in this section, your patience in completing this form is much appreciated.
Thank you !!! 🙏🙏🙏
Part 5: Mini Game

33. 1. How important is it for the website to include the minigame that increase the interaction between system and user? *

Mark only one oval.

- ◯ Very important
- ◯ Somewhat important
- ◯ Neutral
- ◯ Not very important
- ◯ Not important at all

34. 2. What type of minigames would you find most engaging? (Select all that apply)

Check all that apply.

- ☐ Quizzes or trivia about the site's history
- ☐ Scavenger hunts to find hidden artifacts
- ☐ Puzzle games related to historical events
- ☐ Role-playing games (e.g., simulating life in the past)
- ☐ Other: _____

35. 3. How important is it for the minigames to include educational content?

Mark only one oval.

- Very important
- Somewhat important
- Neutral
- Not very important
- Not important at all

36. 4. What other additional feature do you expect in mini game module?

Appendix B: UAT questionnaire questions

Survey of User Acceptance and Satisfaction - Immersive Interaction using Augmented Reality with Exploratory Learning Approach For Lembah Bujang Heritage

Hi, my name is Chow Chong Bao, a Software Engineering student from Universiti Tunku Abdul Rahman (UTAR). This survey is to collect user acceptance and satisfaction evaluation for my final year project 'Immersive Interaction using Augmented Reality with Exploratory Learning Approach For Lembah Bujang Heritage'.

This survey is designed to collect your opinion and feedback on the usability, functionality, suggestions, and overall performance of the system. This survey should take around 5 - 10 minutes to complete, all responses will be kept confidential and used only for research.

Please complete the survey based on the experience during testing. Thank you so much for your time and participation!!

* Indicates required question

1. 1. Gender *

Mark only one oval.

- ◯ Male
- ◯ Female

2. 2. Age group *

Mark only one oval.

- ◯ Below 18
- ◯ 18 - 30
- ◯ 31 - 55
- ◯ Above 55

3. 3. Have you visited a historical site before? *

Mark only one oval.

- ◯ Yes
- ◯ No

Section B: Usability of the system

Please rate each statement from 1 - 5, where
1 = strongly disagree,
2 = disagree
3 = neutral
4 = agree
5 is strongly agree

4. 4. The system is easy to use. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

5. 5. The overall design is visually appealing and user-friendly. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

6. 6. The navigation of the system is intuitive and easy. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Micro

7. 7. The system respond quickly without noticeable delays or errors. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Section C: Evaluation of Each Module Features

This section include evaluation for each module covered in this system, they are:
Module 1: Storytelling module
Module 2: AR module
Module 3: History Corridor module
Module 4: Mini Game module
Module 5: Interactive Map module

Module 1: Storytelling module

8. 8. The story content clear, accurate, and engaging in helping you learn about Lembah Bujang? *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

9. 9. The video and audio playback work smoothly without interruptions. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

10. 10. The navigation between different stories are smooth. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Module 2: AR module

11. 11. The AR feature can be easily access and use with your device *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

12. 12. The 3D models and animations display correctly when scanning the marker/ object. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

13. 13. The AR module is very useful in enhancing your understanding of the site. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Module 3: History Corridor module

14. 14. The timeline / sequence of historical events presented in a clear and logical order. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

15. 15. The design (visuals, text, transition) help you understand the history better. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

16. 16. When browsing the history corridor, there is no issue in loading, readability and responsiveness. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Module 4: Mini Game module

17. 17. The game function normally (drag & drop puzzle pieces, quiz answering, scoring). *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

18. 18. The game make your learning experience more interactive and enjoyable. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

19. 19. The game instructions are clear and easy to follow. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Module 5: Interactive Map module

20. 20. It is easy to navigate and explore the map of historical sites. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

21. 21. The map markers and labels provide useful and accurate information. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

22. 22. The interactive map is helpful in understanding the geographical layout of Lembah Bujang. *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Section D: Suggestion for improvement for this system

Open ended questions, please leave me your comment!

23. 23. Do you have additional suggestions or ideas which would improve this system? (optional)

24. 24. Which aspects do you think are the most useful? (optional)

Appendix C: SUS questionnaire questions

Participant #_____(type: novice/ expert)

System design group:

User Satisfaction survey *(adapted from System Usability Scale, Brooke, J. (1986))*

	Strongly Disagree 1	2	3	4	Strongly Agree 5
1. I think that I would like to use this website/system for booking/ reservation related matter.					
2. I found the website/system unnecessarily complex.					
3. I thought the website/system was easy to use					
4. I think that I would need the support of a technical person to be able to use this website/system.					
5. I found this website/system was easily moved through without a lot of backtracking or data re-entry.					
6. I thought there was too much inconsistency in this website/system.					
7. I would imagine that most people would learn to use this website/system very quickly.					
8. I found the system/website very awkward to use.					
9. I felt very confident using the system/website.					
10. I needed to learn a lot of things before I could get going with this website/system.					

What did you like best about the site? _____

What did you like least about the site? _____

If you were to describe this site to a colleague in a sentence or two, what would you say? _____

Do you have any other final comments or questions? _____