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Research Article

Non-immersive virtual reality for Malay and Islamic world museum Melaka: effects from covid-19 pandemic

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Abstract
This paper describes the development of Non-Immersive Virtual Reality (NIVR) for the Malay and Islamic World Museum in Malacca in Melaka, Malaysia. The Covid-19 outbreak has caused the most impact in the tourism industry in the first half of 2020, and the situation will not be the same as post-pandemic. Thus, we have developed NIVR to attract the tourist or anyone interested in knowing more in-depth information about the heritage culture available in the museum. The application was designed in the 3D environment platform and focused on the Malay warfare weapons, Keris, Lembing, Tumbuk Lada, and Tekpi. We evaluate the motivation of NIVR, particularly towards user experience on the functionality and system usability score. As a result, the system features are functioning, and we manage to get a usability score of 77.08%, which rating as a good score. It means that the NIVR for Malay and Islamic World Museum Malacca system has good system usability since the user can learn more about the artifacts compared to the physical museum where they can only view the artifacts outside the glass container.

Keywords
Covid-19, Malay and Islamic world museum, Non-immersive, Tourism, Virtual reality.

1.Introduction
Tourism has become one of the industries that rapidly developed globally, and heritage-based tourism is Malaysia's potential tourism sector. Ramli [1] claimed the attraction towards archaeology, history, and culture had caused it to become a tourism product. Despite there is no prehistoric heritage in Melaka, many museums were being developed with unique architectures from the era of Dutch (Stadhuys) and A Famosa from Portuguese entrance. The museum is defined as non-profit organizations that provide the collection of materials' evidence of peoples, the environments [2] for studies, educations, researchers, and facilitate knowledge creation with various goals, from supporting the specialist and expert to supporting the public [3].

Department of Museum Malaysia (1993) categorized the museum as the galleries that protect, preserve, and provide information about the nation's cultural, natural, and historical heritage, and indirectly assist in promoting and building up the tourism industry [4]. Several museums, such as natural history museums, art museums, science museums, children's museums, and war museums. Serving and supporting experts such as researchers are moving towards the public.

However, due to the rapid spread virus of Covid-19 and been declared a pandemic, it has significantly impacted the worldwide and the post-coronavirus facing the new ways in global economic, socio-cultural, health-wise, and political effects [5, 6]. The present crisis affected the tourism industry, and currently, both industry and the government play the roles in the recovery actions. Although the

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Movement Control Order (MCO) loosen the restriction on travel and mobility, people still need to follow standard operating procedures such as social distancing, wearing a facemask, and not allowed big crowds at one time. The public has always been reminded of the hygiene and cleanliness concerns [7], and this scenario implies not only the tourism industry but also the future planning and management [8, 9].

Additionally, the ordinary and traditional way of displaying artifacts using texts and pictures caused passive learning activities. Suppose it must be a place where the cultural heritage can be experienced [10], and the displays are possible for the visitors to 'touch' and explore [11]. The artifacts and material collected in the museum collections are risky due to the threat of theft, fire, vandalism, humidity, temperature, and vibration, which caused high maintenance of the artifacts. Other issues and challenges the museum's management faced during MCO were increased sanitization activities and the maximum occupancy regulations. They need to clean and sanitize using a proper protocol and new safety norms due to many interactivities involved during the visit to the museum.

Thus, there is a requirement for virtual conservation of heritage resources technology intervention through the digital storage media and technological museum [12]. 17% of heritage collections were estimated been digitized, according to [13]. Li et al. [14] agreed on the excellent technology used in the digital museum and claimed that only a few studies study the user experience on technology usage. The dynamic, complex, and empowering learning environments can be a great potential for informal and lifelong learning medium [15]. The future role of museums in local and global cultural contexts are being questioned and radically re-shaped. These items are ready through exhibits, which can be temporary or permanent public viewing through exhibits.

This study motivates using a virtual museum, a digital platform that builds on a museum's features to supplement, augment, or enrich the museum through personalization, engagement, user experience, and rich content. Like in a typical museum, a virtual museum may be built around particular objects, such as an art museum or a natural history museum, or may be made up of multimedia exhibits focused on primary or secondary resources. Besides, a virtual museum may be referred to as a smartphone or World Wide Web offers, such as digital representations of its collections or exhibitions, or digital content such as 3 Dimension (3D) environments, net media, virtual reality, and digital art may be created.

Therefore, this study objective is to implement Non-Immersive Virtual Reality (NIVR) using a mobile-based application for the Malay and Islamic World Museum Malacca, Melaka, Malaysia to overcome the mentioned problem. We designed the ideas in a 3D platform and included multimedia elements such as animation, graphics, audio, and text. We are focusing on Malay warfare weapons equipment such as Keris, Lembing, Tumbuk Lada, and Tekpi to give more virtual visual to the audience in the room environment exploration. Then, we evaluate the user experience using the NIVR to ensure we achieve the study's objective.

2.Related works

In this section, we explore the VR techniques and explain the reason for choosing the non-immersive. Then, we make a comparison of the existing application similar to the study.

2.1Virtual reality

Today, VR technology is used to advance medicine, engineering, learning, and entertainment. VR is a computer interface that aims to imitate real-world outside the flat display to give an interactive 3D visual experience [16]. Reconstruction of scales and lengths in static 2D pictures is sometimes challenging. Thus, the third dimension tends to deepen artifacts. Digital reality technology produces interactive worlds that will both teach and entertain customers.

Begun during the 1950s, a cinematographer, Morton Heilig, developed a device that can stimulate all detection, inclusive sight, and sound named Sensorama [17]. In 1968, Ivan Sutherland created a Sword of Damocles and the first VR/AR head roof mounted using PC. Later, many advanced VR was developed and introduced, such as Cardboard VR, Google Daydream, Gear VR, Oculus Rift, Vive, Sony PSVR, and Microsoft's HoloLens [18]. When information technology advances, for corporate and commercialization tasks, such as information distribution, marketing, and sales transactions, 3D virtual worlds have emerged [19]. With digital communication channels that are not limited by geographical boundaries, open virtual world markets promote in-world goods and off-world services, offering a platform for creative use of technology to connect consumers with specific brands and

ultimately influence buying intentions [20]. VR app development has been of major concern these recent times as we have had various people setting up or establishing a VR app development company.

There were three types of VR technology; fully-immersive, semi-immersive, and non-immersive [21], but we only focus on comparing the most used, fully immersive and non-immersive. Immersive VR is a depiction of a simulated reality that substitutes the real-world experience of users sufficiently persuasively to accept reality and truly embrace the generated environment. VR therapy and VR gaming is an essential element of virtual reality applications called immersiveness. VR is commonly used in education and training because of its ability to promote interactivity and motivation [22]. One of the tools used in immersive VR is Cave Automatic Virtual Environments (CAVE), where the user is in a room with all the walls and the floor screens. Users can wear 3D glasses freely to move around in the projected world. CAVE ecosystems are quite expensive due to the requirement of a special non-easily moved space. The features cause difficulties in training and education and to have a widespread application. For example, Cultural Heritage education mainly used CAVE technology [23]. VR glasses or other forms of Head Mounted Displays (HMD) that are often paired with headphones easily create the visceral feeling of living in a virtual environment. Our five senses should be engaged in full immersion in a virtual environment. Nonetheless, most of today's VR experiences only concentrate on two aspects, which are sight and hearing, and do not tackle all the senses. Specifically, as claimed by [24], sight is considered the most important sense, and it is connected strongly with purpose.

Non-immersive VR is a type of technology that provides computer-generated content to users with no sense of immersion in the virtual environment. The key feature of a non-immersive VR device is that users can retain awareness of the physical world while being mindful of what's going on around them, such as sounds, visuals and haptics. Non-immersive VR systems rely on computer or video game console, monitor, and input devices such as keyboards, mice, and controllers. As supported by [25], non-immersive VR makes it possible to communicate with the world using a cursor or joystick, whereas immersive VR uses instruments linked to the human body to execute the same movement activity.

In the 3D content distribution system, the key distinction between immersive and non-immersive VR. Completely interactive VR is a practical simulation platform that helps users to communicate with a simulated 3D world utilizing special haptic interfaces. Unlike non-immersive VRs based on traditional displays, completely immersive VRs include a computer-generated experience through head-mounted displays (HMDs) that separate users from the real world and become unaware of physical objects and sounds. However, the pandemic issue of Covid-19 prevents this project from being implemented in immersive virtual reality to use devices to control the environment.

2.2Review of similar existing application

Many existing applications are available, and this section only focuses on two similar applications to the study. The first application is the 'VR Museum', which gives the user the experience to be immersed in the VR museum, followed by 3D scans of Aztec and Mayan statues as well as gazing into a painting to teleport into the scene. It also transforms the museum experience and redefines how art is created and deployed in the future. The second application, Jurassic VR-Google Cardboard, allows users to experience the ultimate dinosaur ride and free roam the open environment to learn more about dinosaurs back in time. Explore the island's Jurassic shores and dense jungle and learn about this chapter in history. Safely observe the deadly creatures as they prowl their natural habitat.

The comparison is made according to each application's features and elements, as illustrated in *Table 1*. Based on the comparison, the implementation ideas are similar to the Jurassic VR-Google Cardboard and meet the plan of using non-immersive using mobile applications to get attractive usage between the user and the application.

Table 1 Comparison with existing application

Application/ Characteristic	VR Museum	Jurassic VR-Google Cardboard	Malay and Islamic World Museum VR
Content	Transform the museum experience and redefine how art is created and deployed in future	Roam the open environment and poke round the beautiful cedar evergreen trees to see huge dinosaurs become alive. User can go to any point and see the sites and dinosaurs in VR	Allow user to experience the immersive environment in the museum and redefined how the history of Malay and Islam are created such as warfare equipment
Technology	VR in Mobile Application	VR in Mobile Application	VR in Mobile Application
Platform	IOS	Android and IOS	Android
Dimension	3D	3D	3D
Multimedia element	Text, image and sound	Text, image, sound and animation	Text, image, sound and animation
Interface	Lack of interactivity and animation as it appears boring to the user	Easy to use and interact. The graphics are nice, and the animation is quite attractive	Interesting and attractive to use. More interactivity between the user and the application

3.Research method

This section provides an overview of the project methodology used to achieve the goal of the study. The selected model adapted is the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) Model, which consists of five phases: 1) analysis, 2) design, 3) development, 4) implementation and 5) evaluation. ADDIE is considered as dynamic and flexible techniques in developing effective training and supporting tools for performance. ADDIE was selected because it is commonly used in the instructional design field [26] to create an efficient and effective teaching design. Besides, the spin-offs or variations of ADDIE can receive consistent or constructive guidance as teaching materials and are considered an effort to save time and resources.

3.1Analysis

In this phase, we analyze the problem, identify the objectives, and the study's scope. Then, we classify the outcome based on the objective and use it as the input for the design process. Specific software and hardware are identified for development purposes. Three main software selected, firstly Autodesk 3Ds Max and Blender, a professional 3D computer graphics program used to design and create a 3D model character such as visitor (first person), museum, and warfare equipment 'keris', 'tumbuk lada', 'tekpi', and 'lembing'. Second, software Unity 3D, a cross-platform game engine that is used to create a virtual environment. Third, software Adobe Audition, a digital audio editor used to edit and create the application's sound. Fourth, Adobe Premiere Pro was used to create, edit, and trim videos for the warfare equipment. Then all the videos will be exported into Unity 3D. Fifth, Visual Studio is used to edit and debug # files, for example, to move the player, machines, and the button's function.

Two hardware specification parts: 1) design and the development of the application, and 2) the user is running or executing the application. For the development, the specification such as CPU: Intel® Core™ i5-7200U CPU @ 2.50GHz, GPU: Nvidia GeForce 940 MX, OS: Windows 10, RAM: 8GB, and sound card: Aspire E 15. The only difference is the GPU, RAM, and CPU must have the same specifications or above for the user's specification.

3.2Design

Our strategy starts with developing the instruction flow on how to run the system using the flowchart in the design phase, as in *Figure 1*. It functions as the guideline for this study where the application started with the main page displayed, and the user can select the enter button to start the non-immersive VR. Users can play the virtual environment application and manipulate the artifacts followed by the specific video.

3.3Development

In the third phase, we start developing a VR mobile application of Malay and Islamic World museums. The development starts with the homepage creation using Unity 3D in *Figure 2*, followed by creating the museum model using Blender software in *Figure 3*, and *Figure 4* shows how the warfare artifacts are created in Blender and exported into Unity 3D workspace.

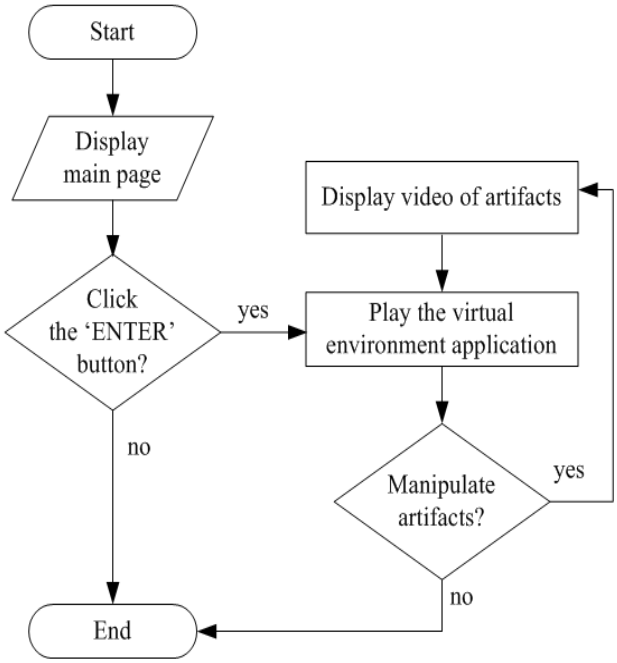

Figure 1 Process flow flowchart on how to run the application of NIVR for Malay and Islamic world museum Malacca

Figure 2 Main menu creation using unity 3D

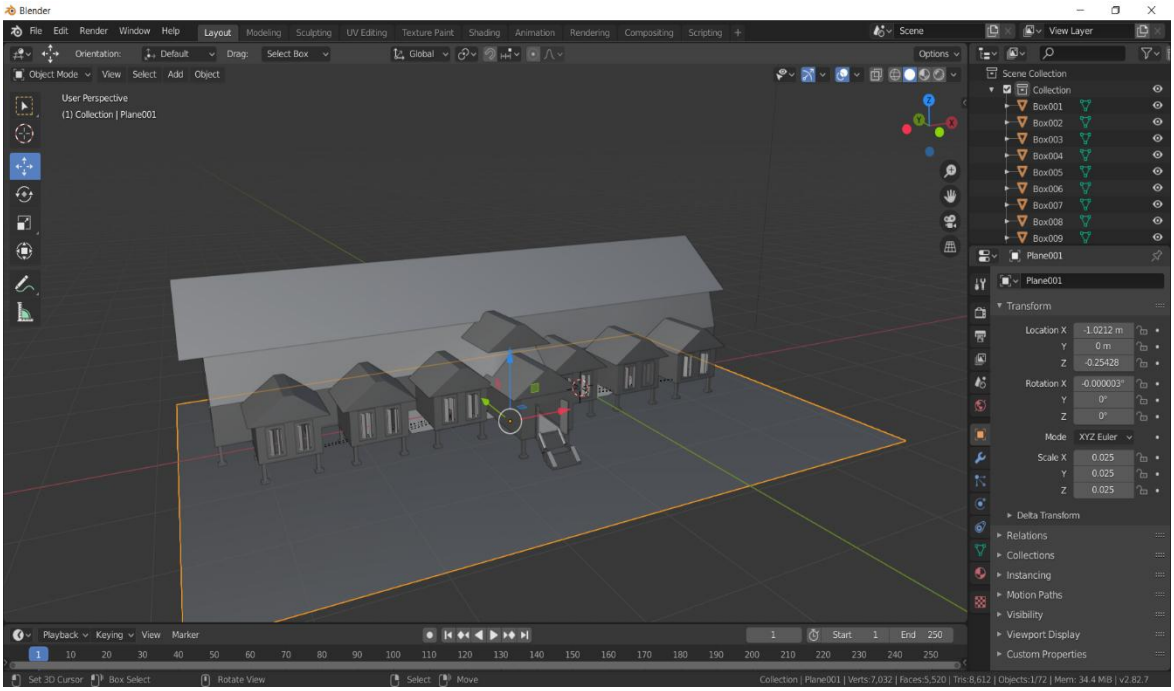

Figure 3 Creation of museum model using blender

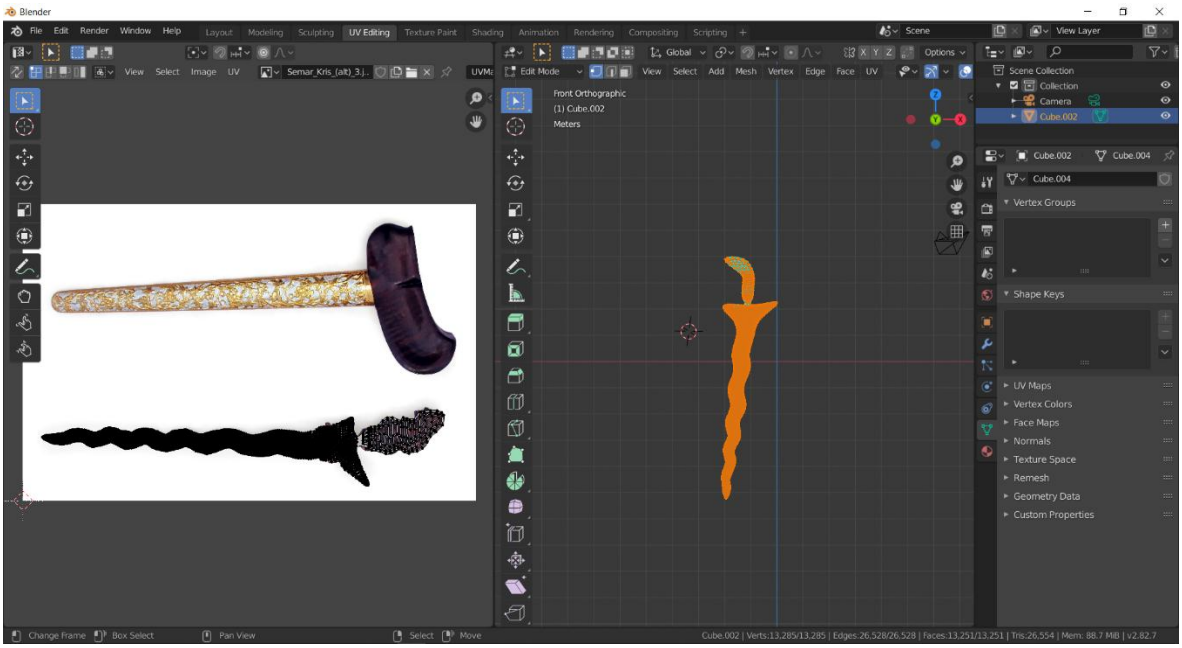

Figure 4 Creation of warfare artifacts using blender

3.4Implementation

The implementation phase refers to the actual delivery of the VR mobile application to the target user. In this phase, the application is revised, modified, and edited to ensure the objective is achievable. This effectiveness of the application result is evaluated time by time.

3.5Evaluation

The last phase in this ADDIE Model is the evaluation phase. We evaluate two types of testing to ensure the effectiveness of the system: functionality and usability. The functionality test involves all the buttons available in the system, and the VR usability tested using the System Usability Scale (SUS) model.

The SUS is a widely used standardized questionnaire for the assessment of perceived usability [27]. We set to collect the minimum number of 30 respondents' feedback due to MCO during the pandemic, and they were selected randomly. Each of them was given 10 minutes to play the application and answer the SUS directly after playing the application. The questionnaire using Google form with Likert-scale one to five represents the 'Strongly Disagree', followed by the rest 'Disagree', 'Neutral', 'Agree', and 'Strongly Agree'.

Due to the alternating sound of the components and the early decision to manipulate the score from 0 to 100, the traditional approach to measurement is quite tricky. This section offers a summary, before reviewing SUS studies, of psychometric approaches for assessment of the accuracy of structured questionnaires, with the focus on validity (the calculation of what a questionnaire measures), reliability (measuring consistency), and responsiveness (the effect of independent variables on measures).

4.Result and discussion

This section presented and discussed the result gained from the highlighted idea in this paper: implementing a mobile-based application using non-immersive VR for Malay and Islamic World museum.

4.1Functionality test

The functionality testing is done by checking the available button in the application and following the museum's exploration. *Figure 5* shows a snapshot of the main menu interface. After we run the application, we can hear the application background music, the button 'Enter', and the museum's text. When the button is selected, the user can explore the museum model for playing the virtual environment in *Figure 6*. At this stage, we can see the museum's name, background music, and animation for the museum model. Finally, the user can explore the warfare artifacts scene in *Figure 7*. The text appears to show the name of the artifacts, background music, animation, and video for each artifact.

Figure 5 Interface of main menu

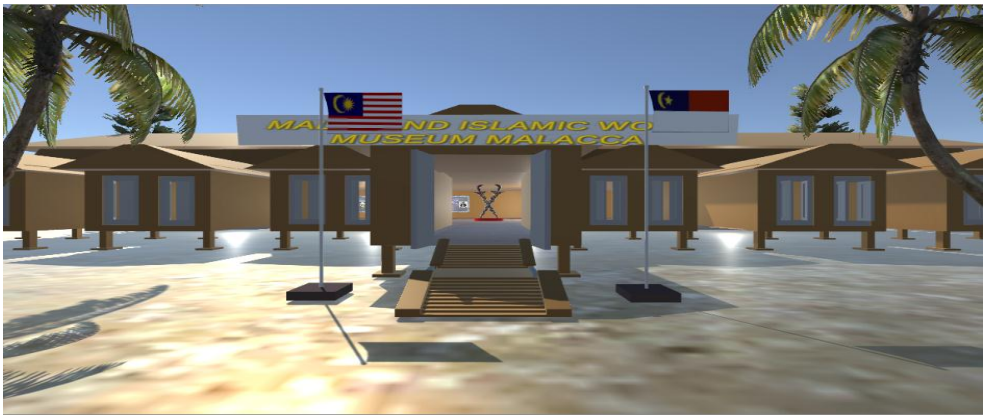

Figure 6 Museum model for playing virtual environment

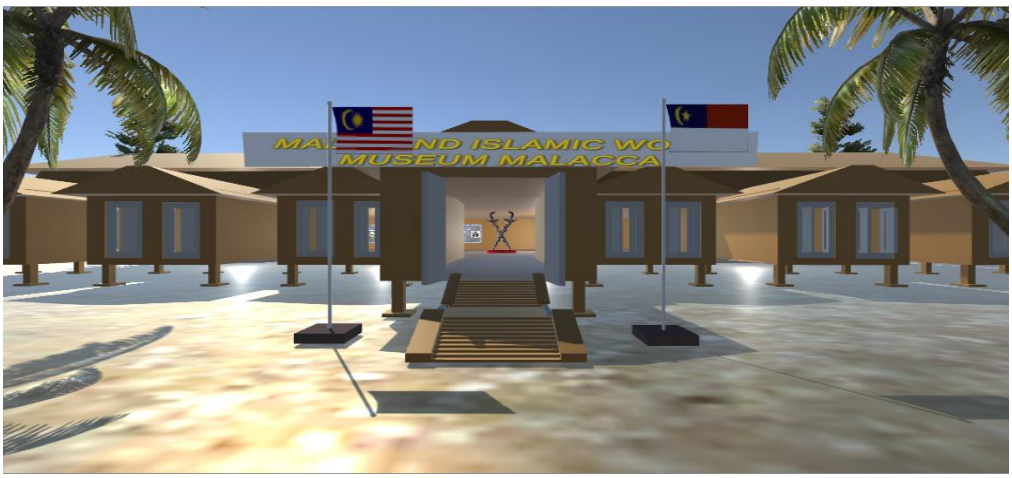

Figure 7 Warfare artifacts scene

4.2Usability test

We summarize the result score as in *Figure 8* for each question. To calculate the SUS result, we need to minus 1 from the scale position for the odd question number. Then, for the even question number, we minus 5 with the scale position. We get the average score from 30 respondents over 40 and multiplied it by 2.5 to get SUS's overall scores. The SUS score result interprets either the system's performance is excellent or poor.

A total score of 2312.5 was obtained from the respondents, and we manage to get 77.08%, an average score of SUS. The histogram in *Figure 9* shows the highest SUS scores of 75% to 80% with 7 respondents. The lowest range is 50% to 60% score with 1 respondent, and the highest range is 95% to 100% score with 1 respondent.

The SUS general guideline stated that the SUS scores range between 68 to 80.3 is 'B grade' with adjective rating 'Good'. Therefore, since this study managed to get an average SUS of 77.08%, which is reaches and exceeded more than 68%, it means that the NIVR for Malay and Islamic World Museum Malacca system has good system usability since the user can learn more about the artifacts compared to the physical museum where they can only view the artifacts outside the glass container.

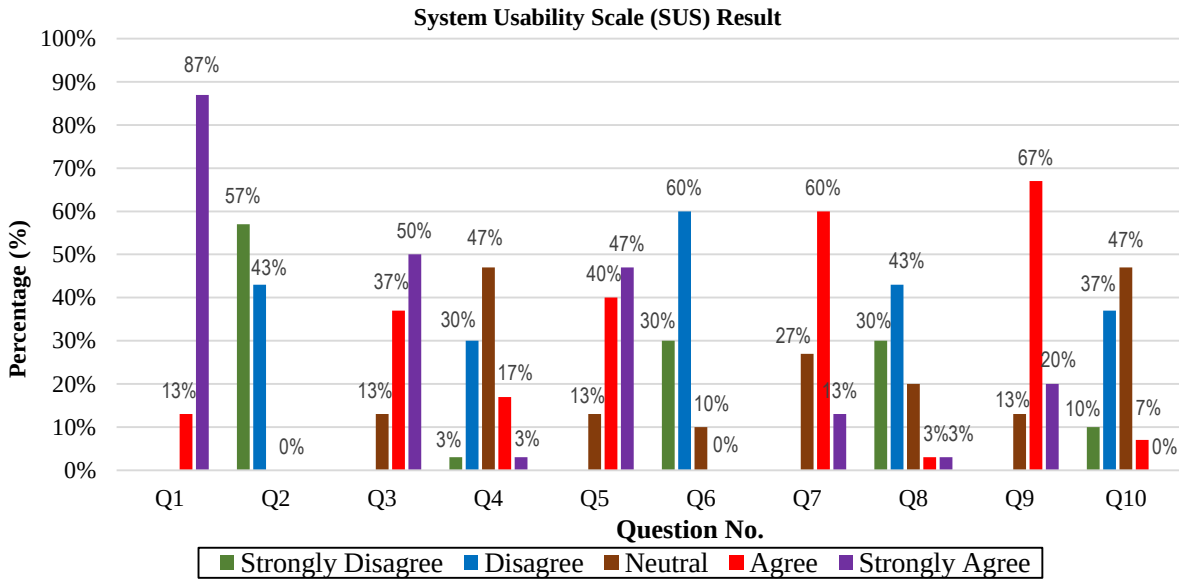

Figure 8 SUS result by question

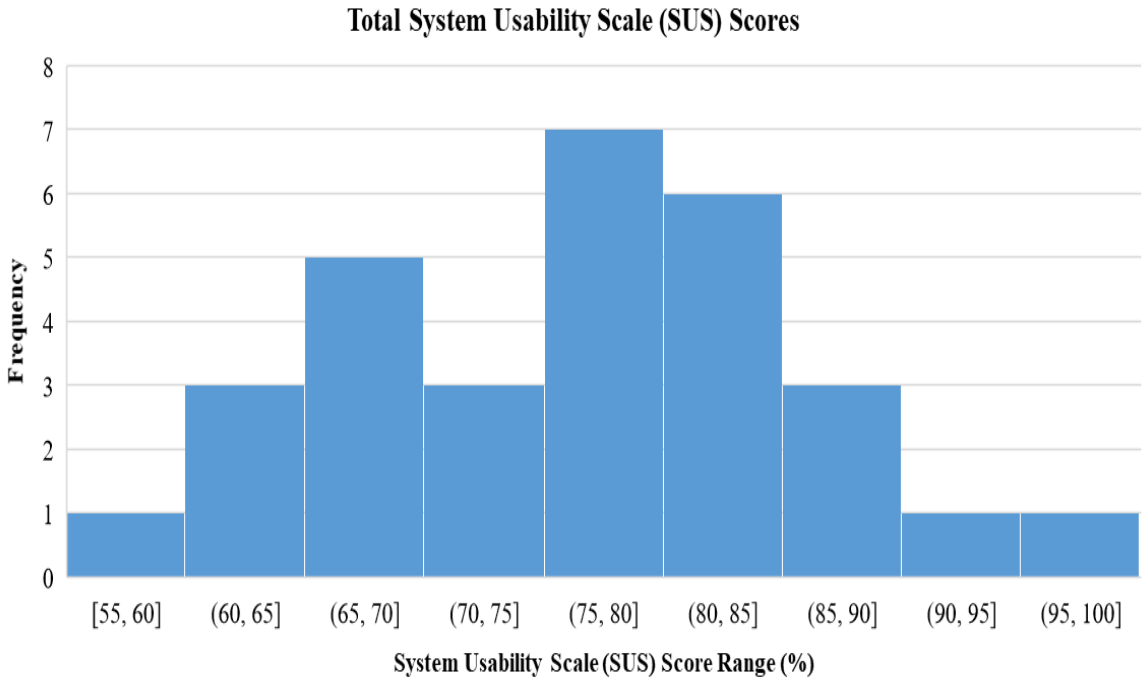

Figure 9 Histogram of SUS scores

5.Conclusion

This paper presents the main aimed to overcome the tourism impacts during the MCO due to the Covid-19 pandemic. The tourist or anyone interested to view the artifacts able to view the environment scene the same as a real physical museum. The case study selected was Malay and Islamic World Museum Malacca, and it proved the application is accepted through the functionality and usability test. NIVR for Malay and Islamic World Museum Malacca is considered a good and accepted system. For future research, it can be improved by manipulating the object and adding more animation to play and interact more with the object.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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