

CHEAM HUEY WEN



Faculty of Cognitive Sciences and Human Development

**A DIGITAL XR - STORYTELLING FOR CAT MUSEUM KUCHING:  
BYOD MODEL**

Cheam Huey Wen

Bachelor of Science with Honours (Cognitive Science)  
2021

BSc Hons (CogSc) 2021



**Faculty of Cognitive Sciences and Human Development**

**A DIGITAL XR - STORYTELLING FOR CAT MUSEUM  
KUCHING: BYOD MODEL**

Cheam Huey Wen

Bachelor of Science with  
Honours (Cognitive Science)

2021

**UNIVERSITI MALAYSIA SARAWAK**

Grade: A

**Please tick one**

Final Year Project Report

Masters

PhD

**DECLARATION OF ORIGINAL WORK**

This declaration is made on the 20 day of JULY year 2021.

**Student's Declaration:**

I, CHEAM HUEY WEN, 65632, FACULTY OF COGNITIVE SCIENCES AND HUMAN DEVELOPMENT, hereby declare that the work entitled, A DIGITAL XR - STORYTELLING FOR CAT MUSEUM KUCHING: BYOD MODEL is my original work. I have not copied from any other students' work or from any other sources with the exception where due reference or acknowledgement is made explicitly in the text, nor has any part of the work been written for me by another person.

20 JULY 2021



CHEAM HUEY WEN (65632)

**Supervisor's Declaration:**

I, DR. REHMAN ULLAH KHAN , hereby certify that the work entitled, A DIGITAL XR - STORYTELLING FOR CAT MUSEUM KUCHING: BYOD MODEL was prepared by the aforementioned or above mentioned student, and was submitted to the "FACULTY" as a \*partial/full fulfillment for the conferment of BACHELOR OF SCIENCE WITH HONOURS (COGNITIVE SCIENCE), and the aforementioned work, to the best of my knowledge, is the said student's work

Received for examination by:



Dr. Rehman Ullah Khan  
Senior Lecturer  
Faculty of Cognitive Sciences and Human Development  
University Malaysia Sarawak

(DR. REHMAN ULLAH KHAN)

20 JULY 2021

Date: \_\_\_\_\_

I declare this Project/Thesis is classified as (Please tick (√)):

- CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)\*
- RESTRICTED** (Contains restricted information as specified by the organisation where research was done)\*
- OPEN ACCESS**

I declare this Project/Thesis is to be submitted to the Centre for Academic Information Services (CAIS) and uploaded into UNIMAS Institutional Repository (UNIMAS IR) (Please tick (√)):

- YES**
- NO**

### Validation of Project/Thesis

I hereby duly affirmed with free consent and willingness declared that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abide interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic and research purposes only and not for other purposes.
- The Centre for Academic Information Services has the lawful right to digitize the content to be uploaded into Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis if required for use by other parties for academic purposes or by other Higher Learning Institutes.
- No dispute or any claim shall arise from the student himself / herself neither a third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student himself/herself without first obtaining approval from UNIMAS.

Student's signature: \_\_\_\_\_

Date: 20 JULY 2021

Supervisor's signature: \_\_\_\_\_

Date: 20 JULY 2021

Current Address:

UNIVERSITI MALAYSIA SARAWAK  
94300 KOTA SAMARAHAN, SARAWAK, MALAYSIA

Notes: \* If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the date of restriction indicated, and the reasons for the confidentiality and restriction.

**A DIGITAL XR - STORYTELLING FOR CAT MUSEUM KUCHING: BYOD  
MODEL**


CHEAM HUEY WEN

This project is submitted  
In partial fulfilment of the requirements for a  
Bachelor of Science with Honours  
(Cognitive Science)

Faculty of Cognitive Sciences and Human Development  
UNIVERSITI MALAYSIA SARAWAK  
(2021)

The project entitled ‘A Digital XR - Storytelling For Cat Museum Kuching: BYOD Model’ was prepared by Cheam Huey Wen and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science with Honours (Cognitive Science).

Received for examination by:



Dr. Rehman Ullah Khan  
Senior Lecturer  
Faculty of Cognitive Sciences and Human Development  
Universiti Malaysia Sarawak

(DR. REHMAN ULLAH KHAN)

Date:  
20th July 2021

<p><b>Grade</b></p> <p>A</p>
------------------------------

## **ACKNOWLEDGEMENT**

First and foremost, I would like to express my sincere appreciation to University Malaysia Sarawak (UNIMAS) for providing a wonderful journey in Sarawak, Malaysia, and an opportunity to study for an undergraduate degree.

Next, I would like to express my sincere gratitude to my supervisor, Dr Rehman Ullah Khan for his consistent and dedicated support in guiding me, that was held virtually throughout my Final Year Project. I would not have completed the study without his valuable knowledge and experiences, patient explanations and feedbacks.

Furthermore, I would like to thank all lecturers of Faculty of Cognitive Sciences and Human Development (FCSHD) for providing multiple helpful workshops for the development of this project. I would also like to thank my seniors for the unconditioned help and advice upon completing the project.

Finally, I would like to express my heartiest gratitude towards my family members and friends for supporting me emotionally, spiritually, and financially throughout my degree.

## TABLE OF CONTENTS

LIST OF TABLES .....	viii
LIST OF FIGURES .....	ix
ABSTRACT.....	xii
CHAPTER ONE INTRODUCTION.....	1
1.1 Overview.....	1
1.2 Background of the study.....	1
1.3 Problem Statement.....	2
1.4 Research Questions.....	2
1.5 Research Objectives.....	2
1.6 Definition of Terms.....	3
1.7 Conceptual Framework .....	4
1.8 Significant of research.....	5
1.9 Scope and Limitation of research.....	5
CHAPTER TWO LITERATURE REVIEW .....	6
2.1 Introduction.....	6
2.2 Traditional Museums.....	6
2.2.1 Concept of Traditional Museums .....	6
2.2.2 Implications of Traditional Museums .....	6
2.3 Modern museums with Augmented Reality .....	7
2.3.1 Concept of Modern Museums with Augmented Reality .....	7
2.3.2 Benefits of Augmented Museum Application .....	7
2.3.3 Research Studies and Examples .....	8
2.3.4 Limitation of Existing Augmented Museum Systems or Application....	11

2.3.5 Suggestions to Existing Augmented Museum Systems or Application..	12
2.4 Technology of Augmented Reality.....	13
2.4.1 Concept of Augmented Reality (AR) and Mobile Augmented Reality (MAR) .....	13
2.4.2 Types of Augmented Reality.....	13
2.4.3 Method of Application in Research Studies .....	16
2.4.4 Benefits of Augmented Reality .....	16
2.4.5 Augmented Reality and its Software Application.....	17
2.5 Storytelling.....	19
2.5.1 Concept of Storytelling.....	19
2.5.2 Application of Storytelling.....	20
2.6 BYOD model.....	20
2.6.1 Concept of BYOD model.....	20
2.6.2 Benefits of BYOD model.....	21
2.6.3 Application of BYOD model .....	22
<b>CHAPTER THREE METHODOLOGY .....</b>	<b>23</b>
3.1 Overview.....	23
3.2 Rapid Application Development (RAD).....	23
3.2.1 Requirement Planning .....	24
3.2.2 User Design .....	24
3.2.3 Development.....	26
3.2.4 Cutover.....	27
3.3 System Flow Diagram.....	28
3.4 Research Framework.....	29
3.5 Research Instrument.....	30

3.5.1 System Usability Scale (SUS) questionnaire.....	30
3.5.2 System Specification .....	30
3.6 Ethics of research.....	31
3.7 Research time frame.....	31
CHAPTER FOUR SYSTEM DEVELOPMENT.....	33
4.1 Overview.....	33
4.2 Design Features .....	33
4.2.1 Font.....	33
4.2.2 Colour.....	34
4.2.3 Icons.....	35
4.2.4 Background Music .....	37
4.2.5 Graphics .....	37
4.3 Vuforia Setup.....	38
4.3.1 Vuforia Installation .....	38
4.3.2 Vuforia License Manager .....	39
4.3.3 Vuforia Target Manager .....	40
4.4 Unity Setup.....	44
4.4.1 Unity Installation.....	44
4.4.2 Vuforia Configuration in Unity.....	45
4.4.3 Unity AR Camera.....	46
4.4.4 Import Target Image Database in Unity.....	49
4.4.5 Unity User Interface .....	49
4.4.6 Unity Scene Manager .....	52
4.4.7 Unity Video Output.....	53

4.4.8 Others.....	54
4.5 Storytelling Components.....	56
4.5.1 Text Transcripts .....	57
4.5.2 Audio Transcription.....	57
4.6 Application Settings.....	58
4.6.1 Player Settings .....	58
4.6.2 Identification Settings.....	59
4.6.3 Resolution and Presentation Settings.....	59
4.6.4 Application Icon Settings.....	60
4.6.5 Build Settings.....	62
CHAPTER FIVE DISCUSSION AND CONCLUSION.....	64
5.1 Overview.....	64
5.2 Testing.....	64
5.3 Evaluation.....	64
5.4 Strength of the System .....	76
5.5 Weakness of the System.....	76
5.6 Recommendation .....	76
5.7 Conclusion.....	77
REFERENCES.....	ix
APPENDIX A QUESTIONNAIRE .....	xiv
APPENDIX B PROTOTYPE.....	xvii
APPENDIX C WHATSAPP MESSAGE SENT FOR DATA COLLECTION .....	xviii
APPENDIX D UNITY PROJECT FILE AND SOURCE CODE.....	xix

## LIST OF TABLES

Table 1. Listed definition of terms.....	3
Table 2. Past studies and real-world examples for museum augmented reality .....	9
Table 3. Types of augmented reality software applications used .....	18
Table 4. System usability scale rating range.....	30
Table 5. The research time frame for augmented reality mobile system in final year project 1 .....	31
Table 6. The research time frame for augmented reality mobile system in final year project 2 .....	32
Table 7. SUS raw data with mean.....	68
Table 8. SUS processed data with score summation .....	69
Table 9. SUS final score with grade .....	70
Table 10. SUS benchmark. Adapted from Quantifying the user experience: Practical statistics for user research, by J. Sauro, and J. R. Lewis, 2016, Retrieved from <a href="http://196.223.158.148/bitstream/handle/123456789/2387/252.pdf?sequence=1&amp;isAllowed=y">http://196.223.158.148/bitstream/handle/123456789/2387/252.pdf?sequence=1&amp;isAllowed=y</a> .....	72
Table 11. SUS benchmark for average and good scores. Adapted from Interpreting Single Items from the SUS, by J. Sauro, 2018a, Retrieved from <a href="https://measuringu.com/sus-items/">https://measuringu.com/sus-items/</a> .....	73

## LIST OF FIGURES

Figure 1. Conceptual framework of the proposed research study. Adapted from AR superpowers, by Alexander, J. (2019). Retrieved from <a href="https://uxdesign.cc/ar-superpowers-b03d1a026bef">https://uxdesign.cc/ar-superpowers-b03d1a026bef</a> .....	4
Figure 2. Rapid application development (RAD) model. Adapted from Rapid Application Development (RAD): Changing How Developers Work, by Kissflow , 2020, Retrieved from <a href="https://kissflow.com/rad/rapid-application-development/">https://kissflow.com/rad/rapid-application-development/</a> .....	23
Figure 3. Storyboard of ARCat.....	25
Figure 4. Low fidelity prototype using Figma .....	26
Figure 5. High fidelity prototype (from left to right and top to bottom) .....	27
Figure 6. System flow diagram for augmented reality mobile system.....	28
Figure 7. Research framework for augmented reality mobile system.....	29
Figure 8. Font templates in Unity .....	34
Figure 9. Colour settings in Unity .....	34
Figure 10. Back icon used.....	35
Figure 11. Settings icon used .....	36
Figure 12. Play icon used.....	36
Figure 13. Implemented custom audio as the background music.....	37
Figure 14. Video editing using Video Editor.....	38
Figure 15. Vuforia Engine Installation.....	39
Figure 16. Vuforia license manager.....	39
Figure 17. Vuforia license key .....	40
Figure 18. Vuforia target manager.....	41
Figure 19. Vuforia create database .....	41
Figure 20. Vuforia adding target into the database .....	42
Figure 21. Vuforia added target into database .....	42
Figure 22. Downloaded database as Unity package file .....	43

Figure 23. Vuforia target image feature .....	43
Figure 24. Unity installation (i).....	44
Figure 25. Unity installation (ii).....	45
Figure 26. Adding Vuforia license key into Unity project.....	45
Figure 27. VideoPlayback scene adding AR camera and image target into the project.....	46
Figure 28. Source code for default and pause mode.....	47
Figure 29. Source code for double tap to focus .....	47
Figure 30. Source code for autofocus.....	48
Figure 31. Source code for flash.....	48
Figure 32. Import and select database into Unity project .....	49
Figure 33. MainMenu scene hierarchy.....	50
Figure 34. Source code for menu functional buttons.....	50
Figure 35. VideoPlayback scene hierarchy.....	51
Figure 36. Source code for back button .....	51
Figure 37. Source code for play and pause functional buttons.....	52
Figure 38. Source code for video output progress bar.....	52
Figure 39. Source code for scene loader .....	53
Figure 40. Import video outputs into Unity project.....	54
Figure 41. Create video output thumbnail by applying texture or material.....	54
Figure 42. Source code for safe area manager.....	55
Figure 43. Source code for ambient light manager in current frame .....	55
Figure 44. Source code for tracking current frame.....	56
Figure 45. Text Reader application in Google Play Store .....	56
Figure 46. Example text transcript used in Text Reader application .....	57
Figure 47. Example audio transcript with chosen language and voice in Text Reader application .....	58

Figure 48. Player settings in Unity .....	58
Figure 49. Identification settings in Unity .....	59
Figure 50. Resolution and presentation settings in Unity .....	60
Figure 51. APK icon used .....	60
Figure 52. Application icon settings in Unity (i) .....	61
Figure 53. Application icon settings in Unity (ii) .....	61
Figure 54. Developer options setup in mobile device .....	62
Figure 55. Build settings in Unity.....	63
Figure 56. Successful built APK .....	63
Figure 57. Ownership of at least one mobile device .....	65
Figure 58. Bring mobile device(s) along with you when heading out.....	65
Figure 59. Ownership of data plans .....	66
Figure 60. Type of mobile service provider for data plans used .....	66
Figure 61. Willingness to download the mobile AR application.....	67
Figure 62. Final System Usability Scale Score.....	71
Figure 63. SUS raw score interpretation range. Adapted from 5 Ways to Interpret a SUS Score, by J. Sauro, 2018b, Retrieved from <a href="https://measuringu.com/interpret-sus-score/">https://measuringu.com/interpret-sus-score/</a> .....	71
Figure 64. Comparison for SUS mean score and target average score .....	74
Figure 65. Comparison for SUS mean score and target good score .....	75

## **ABSTRACT**

The emergence of technology such as Augmented Reality (AR) have been actively exploited for the improved user experience including museums visitation. Nevertheless, mobile augmented reality can be implemented with various added functionalities such as storytelling, Bring Your Own Device (BYOD), navigation, tour guiding, and many more. Several studies have highlighted the application with navigation and tour guiding; however, storytelling and Bring Your Own Device (BYOD) remains least explored. The current study presents a combination of storytelling with local contents and Bring Your Own Device (BYOD) model used in a Mobile Augmented Reality application and its overall usability evaluation at indoor settings. The research uses marker-based Augmented Reality with Rapid Application Development (RAD) and evaluate the usability using System Usability Scale (SUS) questionnaire. This study shows that mobile augmented reality application can portray information of the Sarawak Cat Museum to potential visitors.

# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 Overview**

This chapter reviews the background of study, problem statement, research questions and objectives, definition of terms, conceptual framework, significant of study, scope, and limitation.

### **1.2 Background of the study**

The museums had used different manner to present the exhibition objects and its information within the museum itself physically. Then, there were transitions of the museums over the years from advertising themselves by sending out physical and digital brochures, catalogues, pamphlets, or flyers to visitors to develop applications that are accessible on different mobile devices for visitors to better interact with. The intention of this research study was to overcome problems of one-way interactions and excessive small text readings by incorporating the local contents into storytelling methods with augmented contents using the Bring Your Own Device (BYOD) approach. The augmented elements bring greater effects when it is collaborative with both the storytelling and BYOD methods. There are concerns of implementing augmented reality such as the type of markers, environment conditions, weather conditions, ergonomics, location, and technical conditions, that should be well studied and decided beforehand to develop a practicable prototype. However, limiting factors such as the duration of development time, costs, types of software development kits and application used will affect the feasibility of the prototype. Not only that, but the contents also used for storytelling should be analyzed by identifying the targeted audience for a better outcome. The BYOD method is useful in such a way that it addresses the personalization issue whereby it allows the visitors to better concentrate on interested objects since visitors are more familiar to begin with personal devices, and it will also promote the acceptance of augmented reality technology in Malaysia. Overall, this research is conducted to design and implement a mobile augmented reality system for the Sarawak Cat Museum using marker-based, storytelling, and BYOD approaches.

### **1.3 Problem Statement**

It is crucially important to preserve any functional museum to show appreciation of cultural, scientific, and artistic values that potentially educates the public. From the conventional method, exhibitions bring up concern as it is least attractive and interactive for the public as it is mostly held with one-way interaction. Additionally, the exhibitions were below expectations since it restricts visitors to photographic or audio experiences only while there is a lack of emergence of technology to address the current demands of delivering rich and interactive content to potential (national and international) visitors. Subconsciously, the museums would have tension to bear with sustainable operating performance. However, it is advantageous for museums to improvise with the help of modern technological tools such as augmented reality by including unique local contents and cultural artefacts. As a result, it provides an interactive platform not only to reformat the existing information from the museum but also provides the museum with a greater chance of expansion economically, technologically, informatively, and more aesthetically. Not only that, the use of augmented reality brings more potential visitors even closer from before, by adapting and implementing suitable techniques to display visual information into more dimensions in accustomed new ways of experience. The proposed approach of implementing augmented reality into museum exhibitions in this research study is due to cost-effective implementation, reservation of existing display space of the museum, and potentially avoids large scale renovation and reconstruction of the existing museum.

### **1.4 Research Questions**

1. How to portray information of the Sarawak Cat Museum to potential visitors?
2. How to present the information in storytelling using Mobile Augmented Reality?
3. How practical is the Mobile Augmented Reality storytelling method for the Sarawak Cat Museum?

### **1.5 Research Objectives**

1. To collect the cultural information about Sarawak Cat Museum and digitize it to implement into a Mobile Augmented Reality system.

2. To design and implement the digital cultural information in Mobile Augmented Reality prototype using the storytelling and Bring Your Own Mobile (BYOM) model.
3. To test and evaluate the usability of the Mobile Augmented Reality prototype using System Usability Scale (SUS).

## 1.6 Definition of Terms

Table 1

*Listed definition of terms*

No	Terms	Conceptual definition
1	Augmented reality	A technology that enhances user experience by the mixture of a real and virtual environment with real-time interaction and digital elements (Linowes & Babilinski, 2017).
2	Museum	A non-profit organization that provides a platform for acquiring, conserving, researching, and communicating unique humanity and its environment to serve the community (International Council of Museums, 2007).
3	Storytelling	A process to better engage communication using facts and narrative methods to improvise explanation in a series of contextualized information (Pavlik & Bridges, 2013).
4	Bring Your Own Device (BYOD) model	This concept indicates the usage of personal mobile devices to connect to any related system provided by the organization (Martinelli, Mori & Saracino, 2016).
5	Unity 3D	A development platform that provides a graphic engine and full-featured editor to create applications suited in different physical devices (Linowes & Babilinski, 2017).
6	Software Development Kit (SDK)	A software development tools comprises of various collections of algorithms and device management that aids developers to create applications (Cheng, Chen & Chen, 2017).

## 1.7 Conceptual Framework

This is an illustrated concept map created by Alexander (2019) that comprises of six superpower that is correlated with six user journeys useful for the organization of creative components added for the Mobile Augmented Reality development (*Figure 1.*). In this research study, it is used to clarify, state, and apply selected superpowers (teleportation) at different user journeys (discovering, considering, and using) since it has clear perspectives and between different development stages and allows appropriate considerations to be made for each element, respectively. Teleportation was selected to present digital or augment objects which brings people closer to the futuristic visions on par with local contents and stories, storytelling, and Bring Your Own Device (BYOD) model.



*Figure 1.* Conceptual framework of the proposed research study. Adapted from AR superpowers, by Alexander, J. (2019). Retrieved from <https://uxdesign.cc/ar-superpowers-b03d1a026bef>.

## **1.8 Significant of research**

This research study aims to create a mobile augmented reality system via android platform for the Cat Museum based in Kuching, Sarawak, Malaysia. Different methods have been implemented from past studies to create a highly interactive system to attract more museum visitors. The proposed system can improve the interaction between the museum and visitors and enhance a better and deeper understanding of the information about cultural artefacts. In addition, the visitors can use their mobile devices, provided with appealing graphics, animations, and audio to better perceive, and discover the displayed objects. This will enhance greater attraction and further educate visitors in a highly effective method. The advanced application of augmented reality technology is beneficial to the museum as it leads to the greater interests of the crowds for more potential visitors, especially intentional or young visitors who are cat lovers. It is beneficial to reduce or avoid the immense cost of renovation and reconstruction thus, effectively reserving the existing building architecture.

## **1.9 Scope and Limitation of research**

This research study aims to design and implement an augmented reality mobile system for the Cat Museum via storytelling strategies. However, it was built based on an android platform for users of any android operating system personal mobile devices.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter discusses the traditional museums, modern museums with augmented reality, the technology of augmented reality, storytelling, and Bring Your Own Device (BYOD) model.

#### **2.2 Traditional Museums**

##### ***2.2.1 Concept of Traditional Museums***

The traditional museums are commonly found of an institution that operates for evidential collection of diverse types of valuable objects (value systems, cultural memory, and scientific inquiry) while having to preserve, maintain, and display them at a given space (International Council of Museums, 2007; Pedersen, Gale, Mirza-Babaei & Reid, 2017). The museums exist in two forms, that is public and private institutions, and has a specific time for operation, regular or seasonal (Candlin & Larkin, 2020). Besides, the accessibility of the museums is based on the ticket, government, or non-government organization funding. Also, the museums may have both temporary and permanent exhibitions held according to different themes or seasons. The museum may also be formed in different fields such as arts, history, science, war, medical and so on. A museum is a prominent place for the provision of knowledge across the community and society (Panciroli, Macaуда & Russo, 2018). Pedersen, Gale, Mirza-Babaei and Reid (2017) had mentioned that the preservation and maintenance of valuable objects are a form of knowledge articulation to the audience.

##### ***2.2.2 Implications of Traditional Museums***

Nevertheless, some prominent issues arise after the transitions of technology. According to Hu and Tsai (2016), the conventional method of displaying information is via the usage of physical brochures, catalogues, pamphlets, or flyers that does not reduce paper consumption but also going against the eco-friendly concepts. The conventional display also includes static art with information boards that require ample reading, hence, there is no life-like virtual characters and

social presence (Dang, 2018; Park et al., 2019). Visitors are expected to read the exhibition information boards with small texts and long explanations. This potentially creates a gap between the younger generation (audiences with the existing technology) which provides greater mobility, network access, and interactivity. The lack of understanding for the visitors leads to inflexibility to choose based on their preferences from different series of collections, especially for new visitors. The reduction of visitors may cause lesser income of the museum for its operation and maintenance. Van den Akker (2016) had suggested that the museums should consider the importance of influence that should not be limited to whatever is inside of the museum but also to include the exterior of the museum.

## **2.3 Modern museums with Augmented Reality**

### ***2.3.1 Concept of Modern Museums with Augmented Reality***

From a different standpoint, many museums had revolutionized and picked up modern technology to improvise and attract more visitors (Dang, 2018). The augment visuals can be used and adapt to different environment settings, such as indoors and outdoors (Panciroli, Macaуда & Russo, 2018) but it requires proper implementation and testing. Panciroli, Macaуда & Russo (2018) had also highlighted from all kinds of mobile devices, smartphones were most used in designing and transforming the assigned space for the exhibition of objects into digitalized augmented environments in museums.

### ***2.3.2 Benefits of Augmented Museum Application***

Such technology had shown promising results over the years that it provides greater accessibility and enhances the experience of art and heritage within the digital culture as it is more meaningful and interests the public (Van den Akker, 2016). The creative expression and museum fruition provide unique convergence for knowledge, creativity, and imagination according to immersive modalities to provide engaging interpretation, to present multiple viewpoints, to educate and challenge visitors (Panciroli, Macaуда & Russo, 2018). The use of digital culture also brings such advancement for visitors, including both on-site and online approaches since it prolongs and improves the museum experience rather than becoming a substitution to replace any physical visitation (Roberts-Smith & Ruecker, 2017; Van den Akker,

2016). Not only that, it encourages the visitors to embrace a stylish and cultivated sense of aesthetic, historic, scientific, and cultural value during the visitation (Van den Akker, 2016). In fact, augmented reality technologies offer greater benefits especially for the youngsters to investigate a specific region and its city heritage that are capable of providing refined comprehension and open to new prospects that are memorable (Panciroli, Macaуда & Russo, 2018; Roberts-Smith & Ruecker, 2017). Hence, the visitors need not to divide their attention between the surrounding and the aiding analogue or digital contents (Marques, 2017). The remodelling of virtual elements connects with real-world elements intensify the immersive experience to retrieve the impression of being present for a unique object of illustration regardless of its modes, for indoor or outdoor (Hu & Tsai, 2016; Panciroli, Macaуда & Russo, 2018). Al Rabbaa, Morris and Somanath (2019) had also mentioned that it is practical for specifically directed wayfinding, to gain attraction and attention from the users, and to further encourage art engagement more vigorously. The developed system or application can be used in both settings, on-site and off-site depending on the needs (Hu & Tsai, 2016).

### ***2.3.3 Research Studies and Examples***

According to different experimentations of implementing augmented reality, it is a great technology that leads to positive feedbacks (Fenu & Pittarello, 2018; Ilhan & Celtek, 2016; Marques, 2017; Panciroli, Macaуда & Russo, 2018) since it increases the satisfaction of visitors (Park et al., 2019) and had motivated visitors to obtain more information and experience with the system (Al Rabbaa, Morris & Somanath, 2019; Roongrunsi, Namahoot & Brückner, 2017). It also enhances imagination, emotional experience, and cognitive growth (Panciroli, Macaуда & Russo, 2018), provide more continuity (Fenu & Pittarello, 2018) and repair gap between the visitor expectations and their experience in museum exhibition (Marques, 2017), increase and direct their attention by emphasizing and superimposing (Ghouaiel, Garbaya, Cieutat & Jessel, 2017).

There are a few applications and systems of Augmented Reality used in different museums as listed below: