

**NAMIBIA UNIVERSITY OF SCIENCE & TECHNOLOGY**  
**FACULTY OF COMPUTING AND INFORMATICS**  
**DEPARTMENT OF COMPUTER SCIENCE**



**A PERSUASIVE SOUVENIR SYSTEM (PSS) TO INCREASE NAMIBIAN  
MUSEUMS TURNOUT USING RFID TECHNOLOGY**

By

Ndinelago Tupopila Nashandi  
200513133

THESIS SUBMITTED IN FULFILMENT OF THE DEGREE  
OF MASTER OF COMPUTER SCIENCE  
IN THE

DEPARTMENT OF COMPUTER SCIENCE

AT THE

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

Supervisor: Prof. HN Muyingi

Date of submission: 20/01/20

## **METADATA**

TITLE: MS

STUDENT NAME: N. NASHANDI

SUPERVISOR: PROF. H.N MUYINGI

DEPARTMENT: COMPUTER SCIENCE

QUALIFICATION: DEGREE MASTER IN COMPUTER SCIENCE

SPECIALISATION: SOFTWARE DEVELOPMENT

STUDY TITLE: A PERSUASIVE SOUVENIR SYSTEM (PSS) TO INCREASE NAMIBIAN MUSEUMS  
TURNOUT USING RFID TECHNOLOGY.

MAIN KNOWLEDGE AREA: INFORMATION AND KNOWLEDGE MANAGEMENT, PERSUASIVE  
COMPUTING, COMMUNICATION SYSTEMS, HCI, LOCATION BASED SYSTEMS

KEYWORDS: MUSEUMS, PERSUASIVE SOUVENIR, PERSUASIVE COMPUTING, RFID TECHNOLOGY,  
LOCATION BASED SYSTEMS AND MUSEUMS VISITS

TYPE OF RESEARCH: Applied Research

METHODOLOGY: EXPERIMENTAL PROTOTYPING

STATUS: THESIS

SITE: NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

DOCUMENT DATE: 20/01/2020

SPONSOR: NCRST (CULTURE AND COMPUTER SCIENCE RESEARCH CLUSTER)

## **DECLARATION**

I, Ndinelago T Nashandi, hereby declare that the work contained in the thesis for my Master in Computer Science, entitled 'A Persuasive Souvenir System (PSS) to increase Namibian museums turnout using RFID Technology' is my own original work and that I have not previously in its entirety or in part submitted it at any university or other higher education institution for the award of a degree.

I further declare that I fully acknowledge any sources of information used for the research in accordance with the rules of the Institution.

Signature: NNashandi

Date: 20/01/2020

## **SIGNATURE OF THE SUPERVISOR**

I, Prof Hippolyte N Muyingi, herewith declare that I supervised this thesis.

Signature: \_\_\_\_\_HNMuyingi\_\_\_\_\_ Date: \_\_\_\_20/01/20\_\_\_\_\_

## **Abstract**

An advance in information technology has seen many museums in the world embarking on extensive and continuous developments that can be used to improve visitor experience. The extensive and continuous developments are done by creating an interactive environment that attracts more visitors to museums and sustains their role of imparting knowledge and cultural education (Busch & Sieck, 2015). There are abundant possibilities in addressing low museum turnout. The possibilities range from simple a written guide to a virtual and augmented reality; the increase of handheld devices is more used to enhance visitors' experience within the museum (Hsi, 2004). Initial observation of turnout at Independence Memorial Museum suggests that very few Namibians, compared to foreign visitors, visit local museums. This information is based on statistical data provided by the Independence Memorial Museum, generated from 2015 to 2018, and data from an online questionnaire that was conducted in this study. The data shows that very few Namibian visits museums or do not repeat their visit to museums. Independence Memorial museum, whose impressive multi-story building was inaugurated on the 20th March 2014, revealed that statistics of local museums visitors are low or approximately equal to the number of foreign visitors. Windhoek city has the highest number of inhabitants in the country, with a population of approximately 400 000 (City of Windhoek, 2016). Only 5% of 400 000 Windhoek population visits the museum yearly, making it a worrisome number. The number of students' trips to museums, organised by schools, is also low, with figures dropping from 5 583 learners in 2015 to 3 290 in 2018. This proportion is low, considering the fact that Windhoek has the highest number of schools in Namibia. This shows how Namibian citizens are far away from attaining knowledge that is preserved therein. This also threatens the sustainability of cultural institutions, including museums, as well as their mission of educating the society about their Namibia cultural heritage. This study proposed a possibility of solving this problem through persuasive technology by developing a Persuasive Souvenir System (PSS) that could attract and retain more visitors. The study posits that visitors will spend more time viewing the most attracting or interesting artefact in a museum. Thus, marking

up this experience through a souvenir of the most visited artefact can be a trigger to attract the visitor to revisit the museum. Alternatively, by sharing the experience, the visitor would get friends or close relatives becoming interested to also visit. The system for Namibian museums was developed using C# programming language, and it makes use of identification and tracking technology, which aims to promote and boost the numbers of visitors to local museums by rewarding them with a souvenir card, consisting a photo of them, coupled with their most attracted or interested artefact and description. This system has been successfully developed through a prototyping methodology, and it has also been evaluated. However, due to limited time trial, and taking into account that there is a possibility of visitors taking longer time to decide whether they should visit the museum again or not , the study could not prove if the PSS is indeed able to convince visitors to revisit the museum or new visitors to start visiting the museum. The persuasive component evaluation is part of suggested future works, and it will need to be tested in a long term.

Key words: Museums, persuasive souvenir, persuasive computing, RFID technology, location-based systems and museums visits

## **ACKNOWLEDGEMENTS**

First and foremost, I would like to thank God Almighty for letting me through all the difficulties I experienced during my study. He provided me with good health, courage, inspiration and knowledge to undertake this study. Without his blessings, this achievement would not have been possible. Furthermore, I would like to thank my supervisor, Prof H Muyingi, for providing me with guidance, encouragement and comments throughout the writing process of this thesis. Without him, I could not have completed my study. He has never allowed me to give up.

I am particularly grateful for the assistance given by Dr Irja Shaanika, Mr Aron Hamukwaya and Prof Jose Quenum. I thank them for providing me with suggestions toward this study. I would also like to express special thanks to the Faculty of Computing and Informatics for offering me the opportunity to carry out my study at Namibia University of Science and Technology.

My acknowledgement would be incomplete without thanking the biggest source of my strength – my family and friends. I take pride in thanking my parents for instilling morals and values about life. I would especially like to thank my sister, Martha, for supporting me endlessly. Finally, I owe special thanks to my daughter, Ellen, for the motivation, her patience and helping me to strike a balance between family and studies.

## Table of Contents

<b>DECLARATION</b> .....	<b>I</b>
<b>ABSTRACT</b> .....	<b>II</b>
<b>ACKNOWLEDGEMENTS</b> .....	<b>IV</b>
<b>LIST OF ACRONYMS/ABBREVIATIONS</b> .....	<b>VII</b>
<b>LIST OF FIGURES AND TABLES</b> .....	<b>VIII</b>
<b>CHAPTER 1: INTRODUCTION AND BACKGROUND</b> .....	<b>1</b>
1.1 INTRODUCTION.....	1
1.2 PROBLEM STATEMENT AND ASSUMPTIONS .....	5
1.3 RESEARCH AIM AND OBJECTIVES .....	6
1.4 RESEARCH QUESTIONS.....	7
1.5 RESEARCH LIMITATIONS .....	7
1.6 RESEARCH OUTCOMES .....	7
1.7 RESEARCH BENEFITS .....	8
1.8 THESIS OUTLINE.....	8
1.9 CONCLUSION .....	9
<b>CHAPTER 2: LITERATURE REVIEW</b> .....	<b>10</b>
2.1 INTRODUCTION.....	10
2.2 MUSEUMS AND MUSEUM ATTRACTIONS .....	10
2.3 PERSUASIVE SOUVENIR AND COMPUTING TECHNOLOGY .....	12
2.4 LOCATION-BASED TRACKING TECHNOLOGIES .....	19
2.5 CONCLUSION .....	22
<b>CHAPTER 3: RESEARCH METHODOLOGY</b> .....	<b>23</b>
3.1 INTRODUCTION.....	23
3.2 RESEARCH DESIGN.....	23
3.3 DATA COLLECTION.....	23
3.4 POPULATION SAMPLING .....	24
3.5 DATA ANALYSIS .....	25
3.6 SYSTEM DEVELOPMENT PROCEDURE .....	25
3.7 CONCLUSION .....	27
<b>CHAPTER 4: REQUIREMENT ANALYSIS</b> .....	<b>28</b>
4.1 INTRODUCTION.....	28
4.2 FUNCTIONAL REQUIREMENTS .....	29
4.3 NON-FUNCTIONAL REQUIREMENTS .....	31
4.4 SYSTEM CONSTRAINTS .....	32
4.5 CONCLUSION .....	32
<b>CHAPTER 5: PROTOTYPE/SYSTEM DESIGN</b> .....	<b>33</b>
5.2 THE HARDWARE SETUP OVERVIEW .....	34
.....	34
5.2.1 MUSEUM RECEPTION .....	35
5.2.2 MUSEUM EXHIBITION ROOM.....	36
5.3 SYSTEM ARCHITECTURE .....	38
5.4 DATABASE DESIGN .....	40
5.6 CONCLUSION .....	41
<b>CHAPTER 6: SYSTEM /PROTOTYPE IMPLEMENTATION</b> .....	<b>42</b>

6.1 INTRODUCTION.....	42
6.2 DEVELOPMENT ENVIRONMENT.....	42
6.2.1 Software and hardware requirements .....	42
6.2.2 Development tools .....	43
6.3 DATABASE IMPLEMENTATION.....	53
6.4 CHALLENGES .....	55
6.5 CONCLUSION .....	55
<b>CHAPTER 7: PROTOTYPE TESTING .....</b>	<b>56</b>
7.1 INTRODUCTION.....	56
7.2 TESTING PROCEDURES OF THE SYSTEM.....	56
7.3 FUNCTIONAL REQUIREMENTS .....	57
7.4 NON-FUNCTIONAL REQUIREMENTS .....	57
7.5 TEST PROCEDURES .....	57
7.5.1 Usability testing .....	57
7.5.2 Performance testing .....	63
7.5.3 Security testing.....	63
7.5.4 Acceptance testing.....	64
7.6 GENERAL IMPRESSIONS AND COMMENTS ABOUT THE SYSTEM PROTOTYPE.....	65
7.7 CONCLUSION .....	66
<b>CHAPTER 8: CONCLUSION AND FUTURE WORK.....</b>	<b>67</b>
8.1 INTRODUCTION.....	67
8.2 OUTCOMES OF THE RESEARCH.....	67
8.3 FUTURE WORK FOR THE RESEARCH.....	68
8.4 CONCLUSION .....	69
<b>REFERENCES .....</b>	<b>71</b>
<b>APPENDICES.....</b>	<b>78</b>

## LIST OF ACRONYMS/ABBREVIATIONS

PSS	Persuasive Souvenir System
RFID	Radio Frequency Identification
ICT	Information Communication Technology
GUI	Graphical User Interface
ICOM	International Council of Museums
PTP	Persuasive Text Password
LAN	Local Area Network
ID	Identification
DB	Database
RF	Radio Frequency
XAMMP	Cross-Platform (X), Apache (A), MySQL (M), PHP (P) and Perl (P)

## LIST OF FIGURES AND TABLES

Figure 1.1 Graph of statistic on turnout of visitors at Independence Memorial Museum from 2015 to 2018. ....	2
Figure 2.1 Eight steps in early-stage persuasive design (Fogg, 2009). ....	18
Figure 3.1 The Prototyping Process (Carr, 1998) .....	27
Figure 4.1: Persuasive Souvenir System Use Case .....	30
Figure 5.1: Hardware Setup Overview for the Persuasive Souvenir System. ....	34
Figure 5.2: 2.45 GHZ Active Personnel RFID tag.....	36
Figure 5.3: 2.45 GHZ Gain Adjustable Active RFID Reader.....	37
Figure 5.4: System architecture for the Persuasive Souvenir System. ....	39
Figure 5.5: Logical Data Model for the Persuasive Souvenir System. ....	40
Figure 6.1 : PSS Graphic User Interface: Login.....	44
Figure 6.2: PSS Main Menu .....	45
Figure 6.3: Add artefact form.....	46
Figure 6.4: Add Tag ID form.....	47
Figure 6.5: LifeCam HD300 Camera preview. ....	47
Figure 6.6: Visitor registration form .....	48
Figure 6.8: Return tag form .....	49
Figure 6.9: Museum visitors' visiting journey report.....	52
Figure 6.10 : Persuasive Souvenir .....	52
Figure 6.11: RFID reader connection settings .....	53
Figure 6.12: MySQL Workbench 8.0 .....	54
Table 7.1: Task 1 <Login to the PSS>.....	59
Table 7.2: Task 2<Register a visitor>.....	59
Table 7-3: Task 3<Return Tag> .....	60
Table 7.4: Task 4<Generate souvenir> .....	62
Figure C-1 source code used to connect the RFID tags to RFID readers.....	85
Figure C.2: source code used to extra the tag id for the connected tag and record the time .....	87

## **CHAPTER 1: INTRODUCTION AND BACKGROUND**

### **1. 1 Introduction**

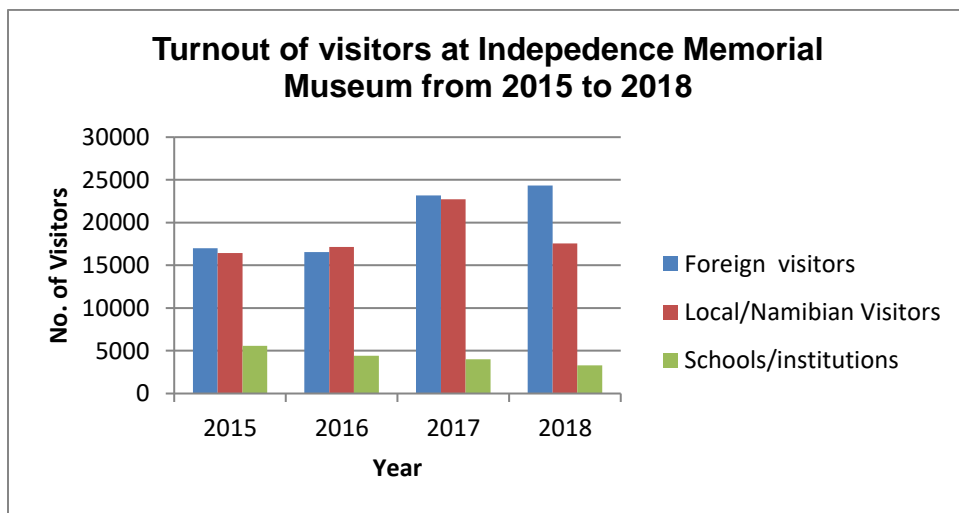
According to the international council of museums (ICOM) statutes (2017), "A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment" (p. 2). Museums aim is to educate the society about cultural heritage and safe keeping of cultural heritages. A couple of years now, museums have become part of leisure places that families usually choose to spend their free time (Hood, 1983). A study by Hood (1983) revealed that people's decisions to visit museums are influenced by various factors such a list of different leisure places to choose from and the benefits that the museum offers to visitors. Hence, there is a need for museums to study visitors' behaviours and what attracts them to museums.

The integration of ICT in all industries has seen many museums in the world embarking on extensive and continuous development of technological approaches to improve visitor experience. This is done by creating an interactive environment that keeps attracting visitors to museums and sustains their role of imparting knowledge and cultural education (Busch & Sieck, 2015). In a museum, an interactive environment is achieved by the engagement between the user and the technology-based media that works according to the user's instructions. This media could be loaded with web application, information technology system, or 2D or 3D virtual media that is able to be controlled by the user in an interactive manner (Dynamic Digital Advertising, n.d; Rajeev , 2019).

For instance, the American Museum of Natural History in New York City uses Bluetooth technology to supply extra instructions through portable electronic devices to gallery visitors on self-governing tour. Additionally, virtual and augmented reality has been

installed at the Franklin Institute of Philadelphia and the Royal Ontario Museum to provide enhanced and insightful involvements within the museums. Such modern ways provide thrilling ways to interact with exhibits in an art gallery (Bettigole, Candanedo, Gencorelli, & Newell, 2017). However, Namibian museums lack such technologies.

The turnout at Independence Memorial Museum by local visitors is very low compared to the foreign counterparts. This information is based on statistical data (Figure 1.1) provided by the museum, which was generated from 2015 to 2018. The data shows that very few Namibians visits museums. The statistics of visitors to Independence Memorial Museum, whose impressive multi-story building was inaugurated on the 20th March 2014, reveal that figures of local visitors are low compared to the number of foreign visitors. Windhoek has a population of approximately 400 000; the highest number of inhabits in the country and the number of visitors to museums is worrisome (City of Windhoek, 2016), as only 5% of 400 000 people residing in Windhoek visit museums yearly.



**Figure 1.1 Graph of statistic** on turnout of visitors at Independence Memorial Museum from 2015 to 2018.

Source: National Independence Memorial Museum’s statistic sheets by Museums Curators, 2019.

The number of school trips to museums is also low, given that Windhoek has the highest number of schools in Namibia. In addition, statistics from the online questionnaire (Appendix B) that was distributed to 40 participants shows that only 50% of these

participants have been to museums and 60% of the participants that has visited the museum have not revisited the museum. This demonstrates that Namibians could be far away from attaining knowledge that is preserved in museums. Even museum workers are concerned by the low turnouts of local citizens to museums. Findings from the pilot study aimed at gathering preliminary data for this study through a conversation with museum curators at Independence Memorial Museum revealed that government is hesitating to provide funds to the museums, since they feel museums are not being utilised by the locals and funds are going to waste (Curators I. M., 2019). Silvester and Pujatura (2016) also confirm that the popular museum guests to Namibian museums are non-Namibians.

With technological innovations, there are abundant possibilities that can be used in addressing low museums turnout. Information technology systems ranging from simple written guide to virtual and augmented reality with increase used of handheld devices are more used to enhance visitors experience at museums and to encourage them to visit museums more often (Hsi, 2004). The past few years have seen remarkable technological advances in different fields, such as the transformation of persuasion theory into persuasive computing technology. Fogg (1999) defines persuasive computing technology as a “computing system, device, or application intentionally designed to change a person’s attitudes or behaviour in a pre-determined way” (p. 27).

Fogg (1998) defines persuasive computing technology as computer software or systems that are developed with the capability of allowing people to interact; as a result, people end up being influenced to change their behaviours or attitudes toward a certain object or actions. Fogg (1998) further emphasises there has been no study on how a computer is capable of influencing people. According to Fogg (1998), the closest explanation is that the influence of computers toward the society is driven by nature and it comes automatically.

The use of Persuasive technology to achieve productive changes has been used in numerous areas, including wellbeing, security and training (Fogg, Persuasive Technologie, 1999). It is also worth mentioning that a rising number of data innovation

applications and administrations are being created to alter users' states of mind and behaviour (Oinas-Kukkonen & Harjumaa, 2009). There seems to be a possibility of solving the current problem of low turnout to Namibian museums through persuasive computing technology by using a persuasive system that attracts more visitors.

The low number of Namibians visiting museums can be addressed by developing and implementing a persuasive souvenir system (PSS). This system for Namibian museums makes use of identification and tracking technology, which aims to promote and boost the numbers of visitors to local museums by rewarding them with souvenir cards consisting of a photo of themselves and that of their most attracted or interested artefact/gallery and a description. The PSS proposed consists of the following hardware: web camera, Radio Frequency Identification (RFID) readers (placed behind each artefact/gallery), tags, routers, printer, computer and a central server. The above-mentioned hardware are used to achieve the following functionalities:

- Router - enables communication between hardware
- Web camera - takes photos of visitors
- RFID tags and reader - track visitors within the museum
- Central server - saves information about the visitor and artefacts/galleries
- Printer - print out the visitors' souvenir card

In order for the PSS to be able to select the most attracted or interested artefact/gallery for the visitor and award the visitors with a souvenir card consisting of the following information: visitor's photo, photo of the artefact and the description of the artefact. Upon entering the museum, the PSS should first capture the following information about the visitor: (1) facial/ID photo and (2) assign an RFID tag ID to the visitor. The PSS could then track the visitor throughout their museum visitation journey, using the RFID technology through the assigned RFID tag. The RFID should connect to the RFID reader placed behind each and every artefact/gallery within the museum. The PSS counts the amount of time a visitor spends admiring or viewing each artefact/gallery and sends the information to the database. The amount of time a visitor spends admiring the artefact/gallery is equal to the amount of time the RFID tag stays connected to a certain

RFID reader. The database is hosted by the central server. At the end, the PSS should select one artefact out of all the viewed artefacts – on the basis that it has the highest viewing time. A souvenir card consists of a photo of the current visitor, their artefact of interest and a description of the artefact generated. The visitor is required to pay a fee in order for the souvenir card to be printed out.

This study posits that when a visitor spends more time in front of an artefact, they are more likely to be attracted or interested in that particular artefact/gallery in the museum. Therefore, a souvenir of the most interesting visited artefact can attract the visitor to revisit the museum. The visitor would also get friends or other close relatives interested to visit the museum. A PSS for Namibian museums aims to promote and boost the numbers of visitors to local museums by rewarding them with a souvenir card consisting of a photo of themselves and that of their artefact of interest, as well as a description of the artefact. The purpose of this study is to investigate whether PSS is a solution toward increasing the number of visitors to museums in Namibia.

## **1.2 Problem statement and assumptions**

Windhoek has the largest number of museums in Namibia (Museums Association of Namibia, 2016) and relatively the highest number of inhabitants in the country, as it has a population of approximately 400 000 (City of Windhoek, 2016). However, it appears that very few people visit museums (Figure 1.1) in Namibia. If the low turnout to museums continues, museums might end up being closed down, there will be a lack of knowledge of different cultures in Namibia, and historical artefacts and inspiration for art may decline. Observation from other countries like Malaysia (Mokhtar & Kasim, 2011), Romania (Zbucnea, 2013), etc indicates that the lack of attractiveness in the content being exhibited by most museums is likely to be the key cause of the low turnout.

**Assumptions:** This study posits that visitors spend more time in front of the most attractive or interesting artefact in a museum. Therefore, a souvenir of the most

interesting artefact visited can attract the visitor to revisit the museum; alternatively, the visitor is likely to recommend the museum to friends or relatives.

Hence the problem statement for the current study is formulated below:

Namibian museums are experiencing a problem of minimal local visitors compared to the foreign visitors. The low number of local visitors has negative implications such as closure of museums, lack of cultural knowledge in Namibian, disappearance of historical artefacts and discouragement for art inspiration hence the current study is meant to resolve the current problem by developing a PSS that's meant to increase the turnout of Namibian museums.

### **1.3 Research aim and objectives**

The aim of this study was to increase the turnout of Namibian museums. The main objective of the study was, therefore, to develop a persuasive souvenir system (PSS) for Namibian museums with the integration of RFID technology. The system can be used to track the amount of time visitors have spent focusing on each artefact of the museum. Based on the PSS, visitors will be presented with souvenir cards containing two components: (1) a visitor's image and (2) the image of the artefact that the visitor has spent most of the time focusing on, as well as the text description of that artefact.

To achieve the aim of the study, three sub-objectives were defined as follows:

- 1.3.1 To establish how artefacts are exhibited to visitors in Namibian museums.
- 1.3.2 To investigate the factors that could impact the use of the persuasive souvenir system in Namibian museums.
- 1.3.3 To design a persuasive souvenir system with the integration of RFID technology and investigate how a computer-based solution could positively influence the number of visitors to Namibia museums.

## **1.4 Research questions**

### **1.4.1 Main question**

How can the persuasive souvenir system (PSS), with the integration of RFID technology for Namibian museums, be developed?

### **1.4.2 Sub questions:**

**1.4.2.1** How are the artefacts of museums exhibited to visitors in Namibian museums?

**1.4.2.2** What are the factors that could impact the use of the persuasive souvenir system in Namibian museums?

**1.4.2.3** How can a persuasive souvenir system (PSS), with the integration of RFID technology, be used as a solution to improve the current situation of low numbers of people visiting museums in Namibia?

## **1.5 Research limitations**

The major limitation of this study was that the researcher could only work with museums within Windhoek because of the costs involved and easy access to the museums. The research setting was chosen on the basis that researcher based in Windhoek. The study focused on the National Independence Museum, which may not be a true reflection of local visitors for all museums across the country. However, the conclusion drawn from this study could be used as a base for future research to find a permanent answer to low turnout in museums. Furthermore, the lack of expertise of the researcher in working with RFID posed difficulties and prolonged the time taken in modelling capability of the RFID tool in regard with fully implementation of the PSS functionalities. Finally, due to the limited time, the proposed PSS will only be deployed in the museum after final evaluation outside this study.

## **1.6 Research outcomes**

This study aims to provide the following outputs:

**1.6.1** Statistic and related patterns of people who visit museums in Namibia.

**1.6.2** An understanding of a possible impact of turnout on cultural institutions – museums.

- 1.6.3 A persuasive souvenir system (PSS) to help in attracting more visitors to museums in Namibia.

## 1.7 Research benefits

This study has the following benefits:

- 1.7.1 It will provide information required by museum employees, especially those who are responsible for managing artefacts and making decisions on which artefacts should be kept and exhibited in the museum. This information is generated from a report on the most and least viewed artefacts by visitors, based on the time visitors spend admiring these artefacts. The artefacts where visitors spend the least time should be replaced with new artefacts/galleries.
- 1.7.2 It will add value to attempts by government officials and non-governmental organisations working on solving the low number of people who visit Namibian museums to find a lasting solution to the problem.
- 1.7.3 It will make valuable academic contributions to the knowledge of the area of research for future researchers, who will enhance find new solutions toward the low turnout to Namibian museums.

## 1.8 Thesis outline

**Chapter 1: Introduction and background** - introduces and provides the background of the study. It also describes the problem statement and outlines the aim, objectives, benefits and the limitation of the study.

**Chapter 2: Literature review** - reviews and gives critical reviews of literature based on the keywords extracted from the research objectives, aim and research topic of the study.

**Chapter 3: Research methodology** - highlights methodology used for data collection and provides a detailed insight of the techniques and methods of data collection, as well as the method for data analysis.

**Chapter 4: Requirement analysis** - presents the functional and non functional requirements for the proposed PSS.

**Chapter 5: Prototype design** - illustrates and describes the prototype design for the PSS.

**Chapter 6: Prototype implementation** - describes the steps and decision made in developing the PSS prototype for the study. The chapter overviews and discusses all major technologies, development environment and tools used in the constructing of the PSS prototype. Moreover, the chapter discusses the implementation of the database used. Finally, the chapter emphasises the challenges and implementation issues that the researcher experienced during the development process.

**Chapter 7: Prototype testing** - presents the testing plan for the PSS prototype and presents the findings or testing results.

**Chapter 8: Conclusion and future works** - summarises and concludes the study. It also identifies directions for future research.

## **1.9 Conclusion**

This chapter was a background of the study, detailing the statement of the problem and outlining the main research questions, as well as the sub-questions of the study. The chapter also elaborated on the objectives of the study that directed the data collection. Moreover, the chapter highlighted the research outcomes of the study, as well as the benefits of the study on developing a PSS system for Namibian museums. The outline of the study was also enlisted, as well as the limitations encountered during the study. The next chapter, Chapter 2 is an overview of literature related to the variables of the study.

## **CHAPTER 2: LITERATURE REVIEW**

### **2.1 Introduction**

This chapter discusses literature based on the keywords extracted from the research objectives of the study, aim and research topic is being discussed. The literature review begins by defining and describing museums, their evolution and benefits of museums in society. Furthermore, the chapter provides literature on the challenges faced by museums. The chapter then reviews the fundamentals of persuasive technology and how it can be applied to increase the turnout of museums. The chapter ends with an explanation and description of existing location-based tracking technologies.

### **2.2 Museums and museum attractions**

According to the International Council of Museums (ICOM) statutes (2017), "A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment" (p. 2). Museums play an important role in educating the society, maintaining national heritage and promoting national identity. Children mostly go to museum for education purposes and adults mostly visit in search of inspiration (Britain Thinks, 2013).

Throughout the years, museums have evolved from merely displaying private artefacts that were meant for high class people and a limited part of the society. Nowadays, museums are open for everyone; however, there is still a challenge of attracting sufficient visitors to the museums (Foley & McPherson, 2000). Arinze (1998) elaborates that:

The challenges that Africa has is that there no interest from the public to visit museums, and this is questioning if the existence of museums should continue or not. There is visible development in other aspects like poverty and famine but museums are still lagging behind. African museums still contain and exhibit materials that are no longer relevant or interest the public and continue to remain

foreign institutions with little significance to the national communities. Some of the artefacts have not been changed for a couple of years and there is nothing exciting or challenging to motivate regular visits. Only a few museums have tried to vary their programmes by introducing positive and educationally valuable activities (p. 33).

It is for these reasons that people in charge of museums ought to understand that individuals do not merely visit museums or any leisure place for the sake of doing so, but the decision on how worthy or valuable the museums are. Thus, it should not be assumed that museums being rated important and different from others are reasons enough for people to visit them. People make such decision depending on what they will get from the museums in terms of a gift and experience (Hood, 1983).

For the couple of years now, it has been acknowledged that gallery learning has the capacity to inspire and enthuse guests while enriching them with fresh understandings and a chance for exploration, but at the same time, going to a historical centre is found discouraging, not influential and it does not attract kids, compared to the choice of going to entertainment gardens, play areas or safari parks (Amran & Admodisastro, 2017).

Since information communication technology has become part of our daily lives and has been embraced well by many institutions to enhance the living condition of the society, museums should also keep up with these technological advancements (Foley & McPherson, 2000). Several studies have been conducted on how to enhance the experience of visitors and to find ways to attract them to museums. Mia (2016) notes that exhibition hall guests and non-guests have been investigated from numerous points of view throughout the years. The purpose of these investigations has varied but the most common results about these studies are that the inspirations of individuals to visit or not to visit the museums changes – and at times, these reasons are the same. Hence, experimenting with various procedures can be the most ideal approach to realise what works in a specific network of people (Mia, 2016). It is apparent that museums have been actively embracing the use of technology by making use of digital and mobile technologies to enhance the guests experience (Amran & Admodisastro, 2017). For this reason, this study chose to employ the persuasive computing technology with tracking and locating

technology, the Radio Frequency Identification Technology, to develop a Persuasive Souvenir Technology (PSS) as a potential solution to the low turnout at museums.

### **2.3 Persuasive souvenir and computing technology**

A souvenir is “something you buy or keep to help you remember a holiday or special event” (Cambridge University Press, 2019, p. 1); whereas the Webster's New World College Dictionary (2014) explains that the term ‘persuasive’ came from a French word *persuasif*, which “came from classical Latin ‘*persuasus*’, defined as “someone or something with the power to convince” (Webster's New World College Dictionary, 2014, p. 1). In the context of this study, persuasive souvenir system is defined as a system that is meant to convince museum visitors to repeatedly and constantly visit the museums and influence others to visit the museums by using a souvenir in a form of a personalised card or photo of their most interesting artefact as a convincing component. This idea is supported by Petrelli, Marshall, O'Brien, McEntaggart, & Gwilt (2017), who notes that a customised tangible gift or memento can prolong the relationship between museums and guests by advertising better approaches for exhibition halls to associate themselves with their guests, connecting them bodily and virtually by the use of technology.

According to Fogg (1999), influence has continuously been a piece of human involvement, example of influencing things or people are such as anthems, book of scriptures stories, guardians and fitness coaches. Individuals have continuously looked for ways to impact others’ demeaners and practices. In spite of the fact that most people oppose the thought of being influenced, they still favour individual who are blessed with influential skills.

Persuasion can be communicated to individuals in three ways –perception, views and conducts. Through perception influence is used to change people’s principles about something or how they think about that particular thing. influence can also be used to change their views towards certain subjects or matters, and lastly, through people conducts, persuasive could be used to change how certain individuals conduct themselves through engagements toward a subject or item (CommGAP, 2006). In the current study, persuasive means are used to influence people’s manners towards

museums. The PSS is designed to influence the way people behave towards museums.

The past few years have seen remarkable technological advances in different fields and so many new technologies have appeared – the persuasion theory is not an exception. Persuasion has developed into a technology called persuasive computing technology, which Fogg (1999) defines as a “computing system, device or application intentionally designed to change a person’s attitudes or behaviour in a predetermined way” (p. 27). It is worth noting that there are pros and cons to every technology development. A computer is capable of persuading people but using technology to influence others also has some measures such as ethical considerations and people should be taught the ability to choose between good and bad persuasive technologies (Fogg, 1999). These limitations and ethical considerations regarding the use of persuasive technology have been explicitly listed, considered and addressed in this study.

The use of persuasive technology to achieve productive changes has been used in numerous areas, including wellbeing, security and training (Fogg, *Persuasive Technologie*, 1999). Furthermore, a rising number of data innovative applications and administrations are being created to alter users’ states of mind and behaviour (Oinas-Kukkonen & Harjumaa, 2009). In recent years, persuasive computing technology research has produced more sophisticated systems that attempt to persuade people in various markets. The most prominent examples is the study by Forget et al. (2008) that involves the creation of a “Persuasive Text Passwords” (PTP), using a pin creation method with influential technology by haphazardly placing a haphazardly picked character into the client’s password. The investigation included a few PTP varieties and 83 members. The system allowed clients to create simple passwords and use the system to strengthen it, helping clients to achieve the required security and avoiding mental beating to come up with a strong password. In addition, Toscos et al. (2006) designed a “chick clique” system that used persuasive technology to convince or influence young ladies who appreciate innovation and need inspiration to keep themselves fit during their pre-adulthood. The system targeted girls, under the assumption that they are likely to become lazy during their transition from childhood to adulthood, and that they are more likely to use unsafe methods to lose weight. This system changed the detached procedure of self-

observing into an agreeable, strong procedure where companions can share individual wellness data and give each other empowering input (Toscos, Faber, An, & Gandhi, 2006). It is evident that many museums in the world have embarked on an extensive and continuous development to improve visitor experience by creating an interactive environment that attracts more and repeated visitors, thereby sustaining their role of imparting knowledge and cultural education (Busch & Sieck, 2015).

It appears there is limited literature regarding the use persuasive technology to influence museum visitors to visit or convince people in their network to visit museums (Forget, Chiasson, Van Oorschot, & Biddle, 2008); (Toscos, Faber, An, & Gandhi, 2006). In other words, there are quite minimal literature that directly includes persuasive technology as a component to increase turnout at museums, despite the fact that scholars have been attempting to find ways to enhance the experience of museum visitors by making use of technologies to make them more interactive and fun.

Available researches that looked at how persuasive technology could be used to influence museum visitors to visit museums are very limited to other continents rather than Africa where Namibia resides. The researcher could not find material written by Africans or developed solutions using persuasive technology that have been implemented in African Museums.

There are various possibilities in addressing the need of increasing the turnout of museum visitors. The choice of employing a certain possibility is depend on the wide varieties of museums and their contexts; systems ranging from simple written guide to virtual and augmented reality, making use of handheld devices have been developed and are more and more used to make museums more interactive.

There have been many studies on finding ways to enhance museum visitors experience. Some of these include the following: Petrelli et al. (2017) presented a paper that outlined the implementation of a system to enhance visitors' experience to museums. The visitors were required to choose a copy of an art of interest. Using the copy of the art, the system was able to record the visitors' journey within the museum, and upon leaving the museum, visitors are required to drop the replica in the box provided. A post card, referred to as a

data souvenir, is printed and handed to the visitors as a souvenir. Petrelli et al. (2017) defines a data souvenir “as the materialisation of the personal visiting experience, dynamically created on the basis of data recorded throughout the visit and, therefore, captures and represents the experience as lived” (p. 281). The postcard included a code that visitors used as a gateway to access additional online materials about the art of interest. The study concluded that more research is needed to be conducted to find out if the information provided is viable to the visitors and if visitors prefer a tangible object instead of online materials. More information should also be provided on how the postcard was created (Petrelli, Marshall, O'Brien, McEntaggart, & Gwilt, 2017).

The study by Petrelli et al. (2017) provides an effective approach to enhance visitors' experience but it limits them, making them to only focus on one story within the museum, while the PSS opts to choose the best artefacts from all the stories within the museums and it is more interactive as it incorporates the visitors' photo with the artefacts, making it more interactive.

Tseng et al. (2018) developed an application aimed at recording and determining the level of visitors' experience at the museum. This information is very important to museum workers as they could analyse it in depth and determine visitors' experience within the museums. The study emphasises that visitors' experience determines the quality of a museum, and it is important that the museum workers are provided with this information to help them to do proper planning and satisfy their clients. There is a high chance that if a visitor has a pleasant experience at a certain museum, they are keen to come back. The experience that the museums offer determines the number of visitors they can attract. The developed system uses “JINS MEME glasses and a micro video recorder to help the curators explore the visitor experience at several touch points during the entire visit journey”. The study concludes that the analysis of eye motion coordination within the museum to particular artefacts could be used to extract information about certain significant moments that visitors had within the museum, enabling them to determine from such information whether or not a visitor had a good experience at the museum; this information is very useful to the museum workers (Tseng, Tang, Shih, & Liang, 2018, pp. 1-5). The difference between the study by Tseng et al. (2018) and this study is that Tseng

et al. (2018) only focuses on recording the visitors' experience for the museum curators, whereas this study goes further to present visitors with their best moment of their visitation to the museum in a form of a souvenir card.

Del Bimbo (2017) presented a paper entitled 'Making a Cultural Visit with a Smart Mate' as his keynote presentation at the 2017 International Conference on Multimedia. The paper gave detailed information about the two prototypes that he developed to enhance visitors' experiences at museums and cultural galleries. The developed prototypes were for inside and outside museums, and their purpose was to provide information about guests' favourite artefacts in a voice format of the guests' spoken language. GPS, with the help of "SIFT features", were used to locate the visitors and the artefacts they are looking at. The prototypes were tested in a museum and the city of Florence. Del Bimbo's (2017) study enhanced visitors' experience with the museum but compared to the system developed in this study, the experience is lived only within the museum. The system created in the current study allowed visitors to be part of the experience and take it home or outside the museum.

Wang, Yang, Lei, Wang, & Meng (2007) presented a Museum Guide System that was made use of handheld devices. RFID was used to navigate and obtain the index number of the exhibit. Visitors were able to move around or sit in the museums and browse the expositive information from their devices. They were given a chance to use their devices to view the content consisting of a detailed explanation of the artefacts and the information were presented to them in forms such as video, audio or photos. This helped them to spend their time in the museum memorising clarified information and appreciating their visit.

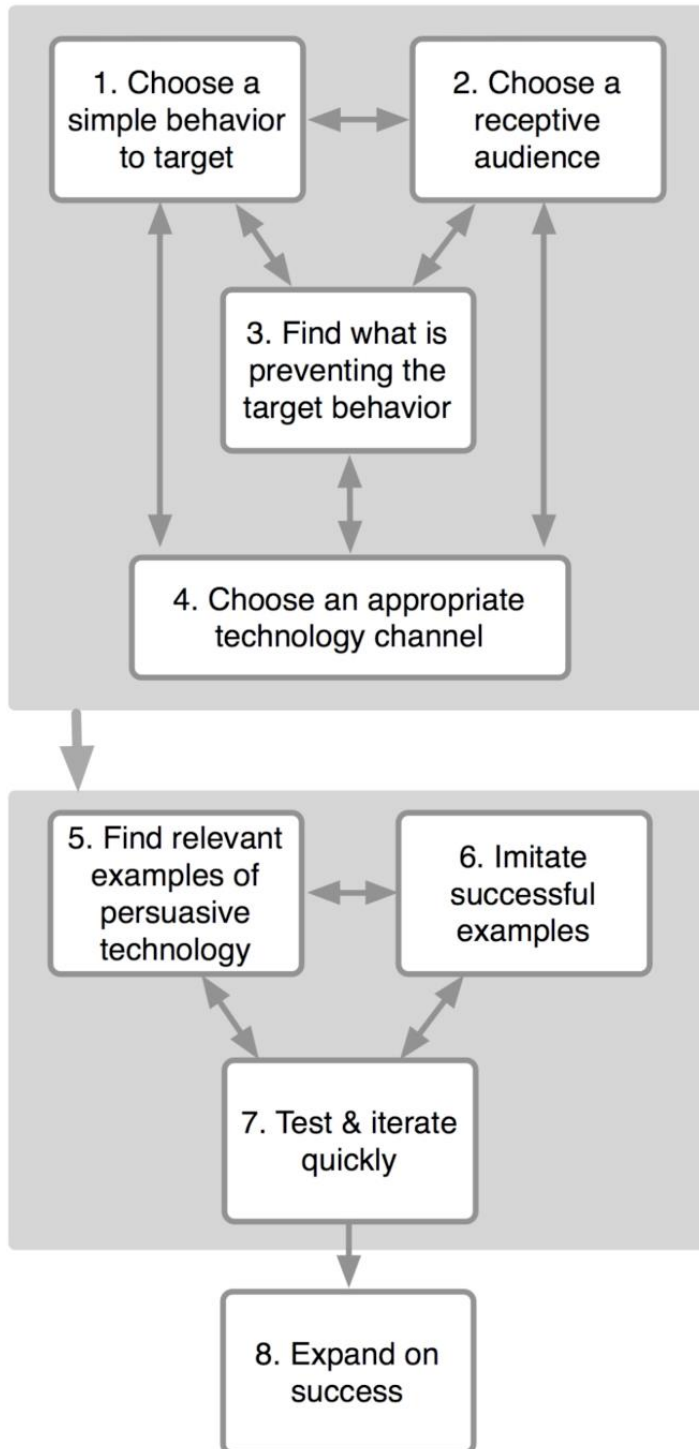
Alexander, Barton, & Goeser (2013) used multi-touch displays fixed in the gallery area to create connectivity between artefacts and visitors through games. The multi-touch screens offered translation and computerised examination of the artefacts. Each artefact within the establishment was translated through narrating hotspots with openings to investigate them and find their uniqueness and their origin. Each interface included

experience arrangement of “games” that welcome guests to interact with artefacts through inquires and involvement with the artefact. Yang et al. (2007) and Alexander et al. (2013)’s systems allowed visitors to look up for more information about artefacts within the museum but their systems only allowed the visitor to live the experience within the premises of the museums, unlike the PSS that allows visitors to take home a souvenir in a form of photo or postcard, making them feel attached to the museums and can easily share the experience with other potential visitors.

Most of the researchers such as Yang et al. (2007) and Alexander et al. (2013) have been often focused on researching on how people could be affluence by directly interact with the persuasive systems. However these studies have one drawback that there is limitation of such systems to only works as catalyst of influence with a limited demographic area. The current study looked at how persuasive systems could extend its influential outside the system usage.

For the creation of persuasive technology applications, Fogg (2009) came up with eight steps (Figure 2.1) that should be followed when creating persuasive technology applications. The steps were extracted from proven working solutions within the business practice; they start with describing the objective of influence to suit an intended audience with a suitable stream of technology. Continue by mimicking effective cases of persuasive design, conducting experiments, measuring behavioural results, and constructing on small achievements (Fogg, *Creating persuasive technologies: An eight-step design process.*, 2009).

Fogg presented a great design to follow when creating persuasive technology applications. However the 5<sup>th</sup> and 6<sup>th</sup> steps suggested that one should find existing relevant examples and imitate them. Hence the design raised an unanswered question of what will one do in a situation where there are no existing examples to imitate?



**Figure 2.1: Eight steps in early-stage persuasive design (Fogg, 2009).** Source: Fogg (2009)

## 2.4 Location-based tracking technologies

Recently, computerised monitoring and locating technology have made ways into art institutions, generally by providing a better set-up to improve the overall performance of electronic guides of guests (Lanir, Kuflik, Sheidin, Yavin, Leiderman, & Segal, 2017). Programmed tracing of the object's position has been a subject of intrigue for a couple of years in different areas. Although GPS has transformed outside location-based administrations, there is no actual standard for great accuracy regarding interior localisation. Indoor position-based frameworks have been moderate to grow for some of the following obstacles: complication of technology, regulatory troubles, constrained precision and extraordinary prices. GPS-like innovations that are responsible for indoor tracking still have a problem with giving a correct figure concerning tracking, so there is a need to look for other fair cost location-based technologies (Baldwin & Kuriakose, 2009). In addition, there are noticeable tested technologies that top the list of fair cost location-based technologies such as RFID, Bluetooth and Wireless LAN (Hightower & Borriello, 2001, p. 1).

At the moment, most studies that aim at investigating when human beings are in motion – either by automobile or by feet – mostly concentrates on outdoor locations and they mainly make use of data from GPS devices (Lanir, Kuflik, Sheidin, Yavin, Leiderman, & Segal, 2017, p. 315). Luckily, with a rapid growth of wireless sensor network, indoor tracking systems are multiplying – even though there is no standardised one being used, but users chose a system depending on its functionalities. “These systems use various technologies such as magnetic positioning, dead reckoning, Wi-Fi, Bluetooth and radio frequency (RF)” (Lanir, Kuflik, Sheidin, Yavin, Leiderman, & Segal, 2017, p. 315).

Even though outdoor human tracking is mostly used, Li et al. (2017) emphasise that “Indoor human tracking is a fundamental component required by a wide range of real-world applications, including security surveillance, physical or behavioural analysis, elderly or patient monitoring, indoor navigation, workspace interaction and indoor space design” (p. 72). Li et al. (2017) presented a paper where they proposed “a device-free human tracking system IndoTrack hosted on cheap commodity Wi-Fi devices”, with the

aim of creating a system that does not require person being tracked to carry any device in order for them to be tracked. This system used a “Novel Doppler\_Music” method to calculate the velocity produced by human movements, a “Doppler-AoA” to put together the calculated velocity and “AoA spectrum information” to find the location of the person. However, this system could only track one person at a time (p. 72).

The system presented by Li et al. (2017) has a good feature that allows the tracking of human with no requirement to carry any tracking device. However the system has one weakness that it can only track one person at a time. The proposed system for the current study required for the possibility to track more than one museum visitor at once.

Hsi (2004) developed a museum-based application that used a low-powered, wireless RFID transceiver called ‘eXspot. The eXspot supports, records, and extends exhibit-based learning. The exSpot application is made up of the following components: front desk for registration, broadcasting equipment that fixed on the artefacts, a Radio-frequency identification card that should carried by the museum’s guest and a private website. The museum’s guest is then responsible to swipe the RFID card to the fixed camera so that information about that certain artefacts could be loaded on their private website. The guest will have a chance to watch their own pictures or learn more about the museum artefacts from a private website.

The system developed by Hsi (2004) made use of RFID as the tracking technology. However it required an intervention from quests to be able pin point the specific information that should be loaded on the personalised websites.

Chen et al. (2013) created an indoor and outdoor tracking system called “Ulocate”. The system was meant to be used by old people with disabilities to monitor their day-to-day routines in and out of the house. The system used radio waves to provide network connectivity with a tag for internal tracking and “GPS Logger“ for outside tracking. They put together the tag and logger to make it easy for the person being tracked to carry it around. Furthermore, they developed a front-end application that was meant to present the participants with a summary of their day-to-day routines. The system was tested in actual houses and the participants showed an interest to use it (p. 174).

Chen et al researched on how they could track old the day to day routines of old people within and outside the house's presented a system that used both GPS and Radio waves for tracking purpose. The approach used here is quite good and Radio waves work well in tracking individuals.

Arulogun et al. (2013) proposed a solution that was meant to eliminate the traditional method of registering attendance for university students since the process was time consuming and full of errors. The study focused on developing an RFID based system that was meant to automatically record students' attendance and for fairness; the system was coupled with fingerprint verification technology. Students were awarded a tag that they should carry around campus and whenever they entered or left the class. The systems captured the arrival and departure time information and sent it to the database for record keeping. The system was meant for Nigerian high education institutions. The researcher intended the system to be adopted by all the learning institutions in Nigeria.

Arulogun et al. proposed solution made used of RFID to track students and automatically record attendance. The system does not require extra work from the students that are being tracked. The system presented a great solution based on this, the researcher decided for the PSS to use RFID as the tracking technology for the museum visitors.

Satoh (2008) presented an M-spaces location model that made used of active RFID Technology to track visitors within a museum. The system was able to play an audio for visitors. The audio was made of explanations of the artefacts that, visitors are currently viewing. The researcher demonstrated the functionalities and efficiency of the system by testing it in a museum. The model has been used in several museums, for example the National Science Museum (Tokyo) and the Museum of Nature and Human Activities (Hyogo) (Satoh, 2008, p. 81). RFID is used in this study because there are numerous benefits associated with its use, compared to other tracking technologies that are used in other studies: RFID can track more than one person at the same time; it is an affordable technology, and there is no extra work required from a tracked person, such as swiping a card for detection.

## **2.5 Conclusion**

This chapter discussed, presented reviews and gave critical reviews of existing literature that are related to the current study. The following literature were discussed; the use of technology to enhance museum visitors' experience, Persuasive souvenir and computing technology and Location-based tracking technologies. The development of persuasive systems has been trending in different aspects of technology, but Namibian museums are left behind in terms of using such technologies to encourage visitors to visit the museums or at least the visitors' experience. This study opted to use RFID for tracking of personnel within the museums for the PSS.

The following chapter highlights methodology used for data collection and provides a detailed insight of the techniques and methods of data collection, as well as the method for data analysis.

## **CHAPTER 3: RESEARCH METHODOLOGY**

### **3.1 Introduction**

This chapter presents and describes the research design in the study, providing a detailed insight of the techniques and methods of data collection and the approach for data analysis. The chapter also outlines the population and sampling of the study. Researchers are involved in investigations to find solutions to identified problems and contribute new ideas to existing knowledge; thus, most researchers have defined research according to their field of knowledge. Kothari (2004) defines research as a logical approach that involves identifying the problem, conveying a hypothesis, gathering records or information and coming up with a particular inference in a form of answer(s) for an identified problem or a base for future work. Kothari (2004) further elaborates that what drives researchers to conduct research is to come up with solutions to research questions by using a group of different techniques put together to help acquire new and quality knowledge. For research to be concluded, the research questions should be answered and a plan on how to answer those research questions should be drawn. This chapter describes research approaches and research designs that guided the study.

### **3.2 Research design**

Creswell (2009) defines research design as strategies and techniques used to conduct research. These strategies and techniques cover the whole process of turning the general supposition to well-articulated approaches adopted for data gathering and evaluation (p. 36). Moreover, Creswell (2009) refers to research design as a “plan or proposal to conduct research” (p. 38). This study employed the experimental research method preceded by a baseline study of the National Memorial Museum in Windhoek, and literature review to achieve the objectives of the study.

### **3.3 Data collection**

O’Leary (2004) defines data collection methods as procedures that the researcher utilises to gather facts. The mixed data collection method was adopted for the study to increase

the scope and range of the data, in order to address the research problem and answer research questions. The study used both qualitative and quantitative data collection methods. Qualitative methods allowed the researcher to collect large amount of verbal and written information from the respondents to gather data pertaining to the research problems and questions. The researcher conducted a baseline study of National Independence Museum visit, an observation and took field notes. The purpose of observation was to understand how artefacts are exhibited in the museum, where the researcher observed the behaviours of museum visitors towards artefacts. The researcher was also interested in finding out whether there are existing persuasive computing technologies at the museum to attract visitors. Observation as a method of data collection method allows researchers to gather data through their senses (O'Leary, 2004). Qualitative information was then converted to statistical data and analysed.

A in addition to observation, the researcher also used a web-based questionnaire (Appendix B), which consisted of structured and semi-structured questions to collect quantitative data. The questionnaire was based on the following questions:

- Do Namibians visit museums?
- How many visitors have gone back to the museum after their first visit?
- How do potential and current museum visitors' feel about the proposed PSS?
- Are they comfortable with being tracked within the museum?
- What ideas could potential and current museum visitors suggest in connection with the introduction of information technology in the museum.
- At which level could current museum visitors rate the current information technologies that is currently implemented in Namibian museums?
- Do potential and current museum visitors see the need to improvement the information technology in Namibian museums?

### **3.4 Population sampling**

For a researcher to be able to answer research questions, data should be collected from a sample selected from the target population (Creswell, 2009). Mugo (2002) defines a

sample as a “set of respondents (people) selected from a larger population for the purpose of a survey” and population as “a group of individual persons, objects, or items from which samples are taken for measurement” (p. 1). This study used the random sampling to select the participants for the study, where each individual in the Namibian population had an equal probability of being selected (Creswell, 2009). The target population of the study was all Windhoek residents because the researcher resides in Windhoek. A total of 40 participants from Windhoek participated in the web-based questionnaire. Moreover, five staff members from the National Independence Memorial Museum were also sampled and they participated in the study.

### **3.5 Data analysis**

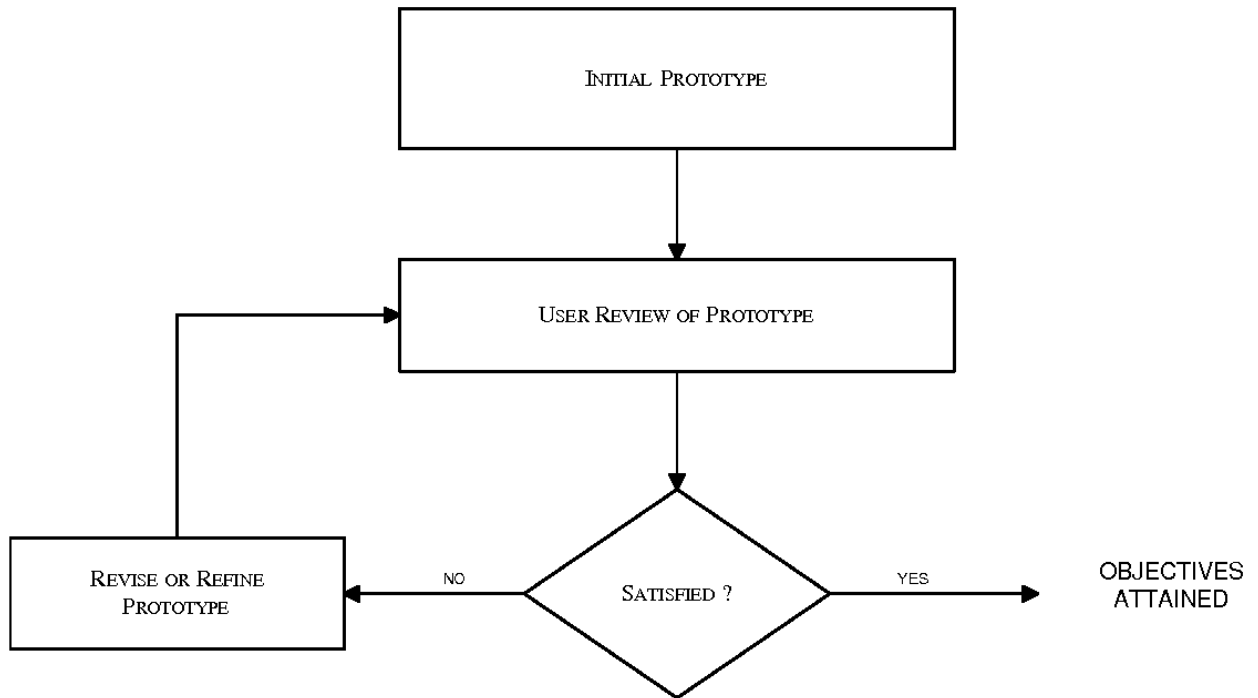
Creswell (2009) defines data analysis as “the process that involves making sense out of data by collecting open-ended data, based on asking general questions and developing an analysis from the information supplied by participants” (p. 184). This collected and interpreted qualitative and quantitative data. The data were interpreted by validating the accuracy of the information by means of reading through all data and then finding patterns between the data. This interpreted data was then used for the development of the Persuasive Souvenir System.

### **3.6 System development procedure**

The process adopted for the development of Persuasive Souvenir system is evolutionary prototyping. According to Pomberger and Weinreich (1994), “software prototyping is a bottom-up process: a few (simple) basic functions are implemented quickly, tested by the user, and improved, then additional user requirements are implemented and the cycle continues until the product is finalised” (p. 3). During this process, staff members at the National Independence Museum acquired an understanding of the functions of the complete system and they could request for changes or identify additional requirements. The first prototype was created based on the results from the data collected through the observation session during the visit to the Independence Memorial Museum and the analysed data from the web-based questionnaire that was circulated earlier. The

prototype allows users and the researcher to test the system until all the requirements and proposed changes are incorporated (Pomberger & Weinreich, 1994).

An evolutionary prototype is built when overall requirements are not well understood, and it is good for new technology like the one for this study. The PSS is new to the Independence Memorial Museum. In order for the researcher to present an overview of how the final system would look like, the prototyping approach was then adopted. The prototyping approach has an advantage over the classic software development process because the classic software development process enforces that the next phase can only start after the previous one has been finalised. The enforcement makes it hard to incorporate changes that are requested by the user at that moment. The requested changes will have to wait and be incorporated only at a later stage (Pomberger & Weinreich, 1994). Evolutionary prototyping serves to introduce the element of communication and feedback; hence, the user involvement in the development is guaranteed. It allows the user and the developers to generate the final requirement essential for the final system during the testing phase, compared to the traditional approach where by requirements should be completed before the system development begins (Floyd, 1984). Figure 4.1 illustrates the process involved in developing a system using the prototyping approach.



**Figure 3.1: The Prototyping Process.** Source: (Carr, 1998)

This study also used Fogg’s (2009) persuasive design system shown at page 19 as a base to create the PSS.

### 3.7 Conclusion

This chapter discussed the research design employed in this study, provided a detailed insight of the techniques and methods of data collection and the approach for data analysis. The chapter also outlined the population and sampling of the study. The experimental method was employed to conduct the study. The mixed data collection procedure was also used to collect both qualitative and quantitative data. The data were collected through observations and questionnaire as data collection tools. The next chapter presents the functional and non-functional requirements for the proposed PSS.

## CHAPTER 4: REQUIREMENT ANALYSIS

### 4.1 Introduction

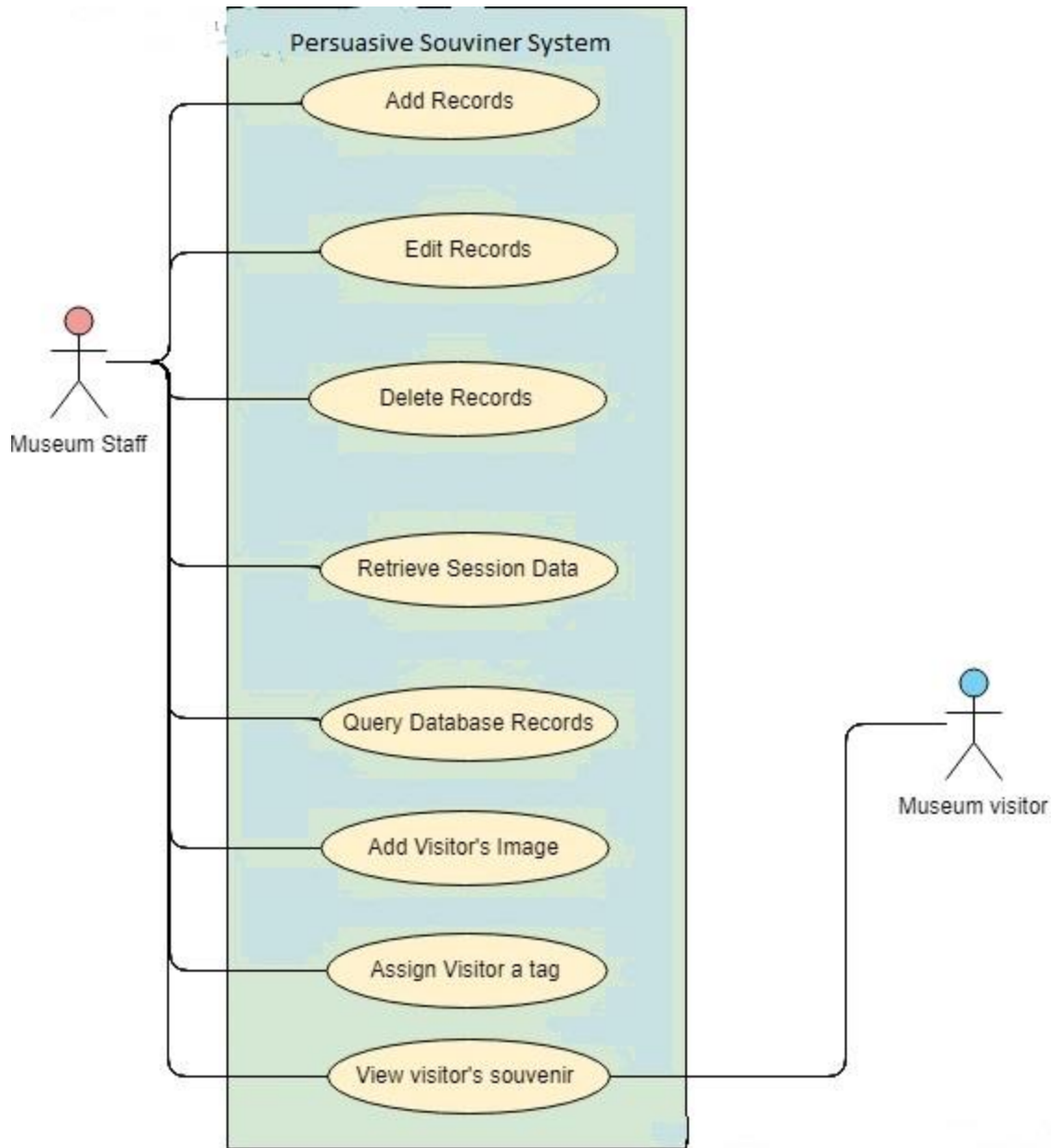
Requirement analysis is a very important stage in every software development process because it determines the success of the application. In other words, the failure or success of the final product depends on whether or not the right requirements were classified. Wrong requirements can lead to the development of a system that is already unsuccessful (Sunner & Bajaj, 2016). Requirement Analysis is a process of defining the purpose of the application (Summers, Joshi, & Morkos, 2014). According to Sunner and Bajaj (2016), requirement analysis is divided into two types: functional and non-functional requirements. The functional requirement defines activities that the computer program would be capable of executing. It could also be expressed as requirements that defines what the system is required to perform or actions that the system must execute to offer its clients with a specified service. On the other hand, the non-functional requirements reveal in what manner the computer program must function when in terms of quality (Mohammad, Peck Lee, & Parizi, 2015, p. 6). Functional requirement deals with the tasks that the system should deliver, whereas the non-functional requirement is concerned with the associated constraints that may prevent the system from functioning well (Sunner & Bajaj, 2016). Non-functional requirements are associated with features or standards that a computer program is required to have during the execution of the specified task. A computer program can function without satisfying all the specified requirements. However, a computer program that does not meet the required non-functional requirement can be declared inoperable (Mohammad, Peck Lee, & Parizi, 2015, p. 6).

In addition, the requirements can also be classified into User and System requirement. User requirements describe what the system should be able to perform or accomplish from the user's point of view. The user requirement contributes to the generation of the system requirements, whereas the system requirements describe the prerequisites of the system at the framework level that depicts the tasks which the framework ought to satisfy to fulfil the customers' needs and necessities. System requirements are constraints that have been imposed on the system by the customer (SEBoK, 2019).

This chapter documents the functional and non-functional requirements for the persuasive souvenir system (PSS) that was developed for this study. The requirements for the initial prototype system are based on literature reviews, as well as from the findings of the study from the online questionnaire. Conversation with Namibia Museum Management staffs revealed that they have trust in Namibian youth to develop computerised solutions to enhance the museum experience and boost the number of museum visitors; hence, the current study researched on how come up with the most reliable solution – the PSS.

## **4.2 Functional requirements**

After careful analysis data from the online questionnaire and observation of visitation of museum visitors at the Independence Memorial Museum, the following functional requirements for the PSS prototype were derived and transformed into the use case diagram as shown below:



**Figure 4.1: Persuasive Souvenir System Use Case**

Figure 4.1 reflects the functional requirements for the PSS by means of use cases. The represented use cases are elaborated below to describe the interaction required to take place between the user and the system:

- Add records** - This use case begins when the museum staff identify the photos of the artefacts, tag ID or RFID readers they wish to add to their list. The staff then add the records to the system and the system will add send it to database.

- **Edit records** - The museum staff identify and select from the list of photos of artefacts, tag ID or RFID readers in the system they wish to edit their details. They then proceed to update the details and system captures the new details into the database.
- **Delete record** - Staff identify the photo of the artefact, tag ID, visitor's photo or RFID readers they wish to remove from their list. The staff select the data they wish to remove from the list in the system. The system then removes the given data and updates the database.
- **Retrieve session data** - the staff identify the information they wish to retrieve from their list. The staff select the data they wish to display from the list in the system. The system then displays the selected data from the database.
- **Add visitor's image** - The staff use the system to take a picture of the visitor and the system will then send the photo to the database.
- **Assign visitor a tag** - The staff use the system to assign a tag to the visitor and the system sends the tag ID to the database, associating it with the visitor's photo.
- **View visitor's souvenir** - The system displays the visitor's souvenir in a form of a photo to the staff and museum visitor. The staff will then use the system to print the photo upon the visitor's request.

### 4.3 Non-functional requirements

Non-functional requirements are occasionally referred as quality attributes or quality requirements of the system (Mohammad, Peck Lee, & Parizi, 2015). The following non-functional requirements have been identified for the PSS that was developed for this study:

- **Availability** - The system should be readily available whenever a user would like to use it.
- **Usability** - The museum staff have minimal knowledge about computers; hence, the system should require little effort to learn and use.
- **Maintainability** - The system should be flexible and able to adapt to requested changes.

- Security - only museum staff should have access to the system, based on the level of privilege and access rights granted. Data in the database may only be changed by the system administrator.
- Performance - responsiveness time of the system should be fast enough when various users are interacting with the system.

#### **4.4 System constraints**

The following constraints have been imposed on the system by the user requirements where the system is supposed to operate:

- Proximity - The user requires that the system just reads a tag up to 1 meter but the Adjustable GOA Reader used to read tags in the study can read tags up to 100m proximity range and can only be adjusted until the range of 5 meter.
- Number of tags to be read - The GOA Reader used in the study could only read 100 tags at a time.
- Reading time delay - The system requires data from the tag to the reader to be transmitted in real-time but there might be some delays in some cases. The RFID tags and readers selected for the study is of high frequency but cannot guarantee that there will not be any delay.
- Reading range - Tag may be read outside the reading zone or not read while in the reading zone.
- Intersection zone - If the visitor holding a tag enters an area where the two reading zone overlaps, the tag might be read by two readers at the same time.

#### **4.5 Conclusion**

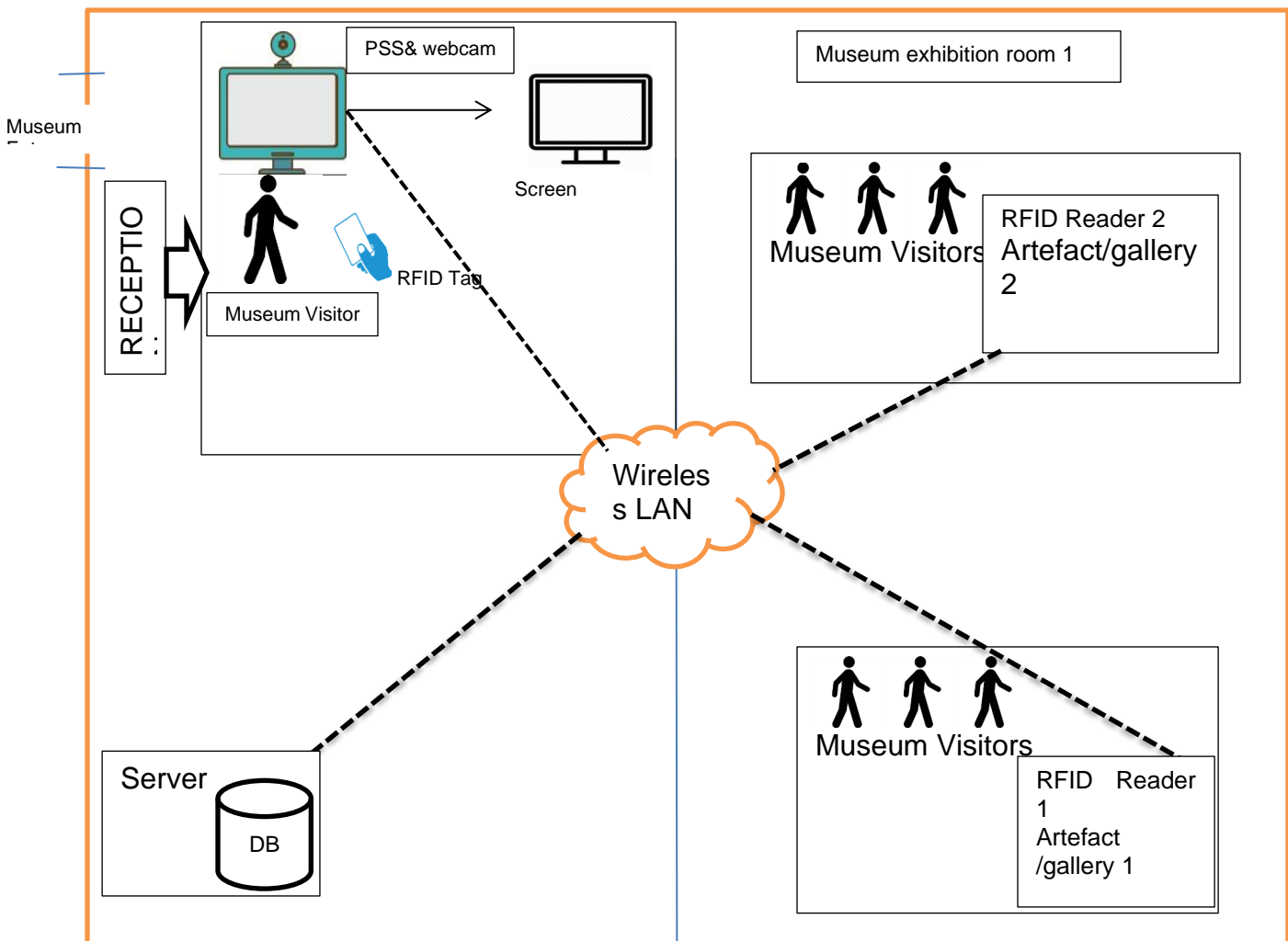
This chapter presented functional and non-functional requirements for the proposed PSS and outlined the constraints within which the system is supposed to operate. The functional requirements for the PSS prototype have been transformed into a use case diagram (Figure 4.1). The identified, listed and described non-functional requirements for this study are Performance, usability, availability, security, and maintainability. The next chapter illustrates and describes the design for the proposed PSS.

## **CHAPTER 5: PROTOTYPE/SYSTEM DESIGN**

### **5.1 Introduction**

Adhiambo (2018) defines system design as “the process of designing the elements of a system such as the architecture, modules and components, the different interfaces of those components and the data that goes through that system”. The bond between requirement analysis and the final system is usually created according to the requirements represented by the system design. The objective of the system design is to create a graphical replica of the system that can be utilised during the development phase (Thakur, Discuss the Objectives of the Design Phase, n.d). This chapter illustrates the hardware setup overview, system architecture and database design of the Persuasive Souvenir System (PSS), based on the requirements that were defined in Chapter 4.

## 5.2 The hardware setup overview



**Figure 5.1: Hardware Setup Overview for the Persuasive Souvenir System.**

Figure 5.1 represents the hardware setup overview for the PSS. It shows the hardware part of the PSS and how they are interconnected to allow the system to function properly, based on the functional and non-functional requirements that were identified in Chapter 4. Below is a detailed description of how the hardware for the PSS must be setup in the museum: it should be located in different rooms, made up of the reception and different exhibition rooms.

### 5.2.1 Museum reception

As shown in Figure 5.1, the reception has the following hardware:

- **Museum staff terminal** - The PSS is installed in this terminal, where a museum staff is required to sit and use the system.
- **Webcam** - The webcam is connected to the terminal and it is responsible to take the visitor's photo. The PSS system sends the picture to the database. The visitor's photo is only taken if the visitor agrees; otherwise, a default picture of a Namibian flag is used as an alternative.
- **Screen** - The extra computer screen is also connected to the terminal. The extra screen is responsible to display the visitor's souvenir in a form of photo or card, consisting of the visitor's most interested artefact and his/her image, as well as the amount of time spent in front of that particular artefact.
- **RFID tag** - The RFID tag is given to the visitor after the museum staff have asked the visitor whether or not they are comfortable with being tracked. If the visitor agrees, the staff procedurally takes a photo of the visitor. Each visitor is assigned a tag ID, which enables the visitor to be tracked through his museum visitation journey. Each time a visitor enters a reading zone, the connection between the tag and the reader is established. The PSS then starts to calculate the amount of time spent viewing that artefact.

The 2.45 GHz Active RFID card tag (Figure 5.2) used in this study has the following capabilities (GAO RFID Inc, n.d):

- up to 100m of reading range.
- Unique anti-collision feature that allows for a simultaneous read of up to 100 tags (GAO RFID Inc, n.d).
- Uses radio frequency energy to communicate with RFID readers (GAO RFID Inc, n.d).
- Embedded power.



**Figure 5.2: 2.45 GHZ Active Personnel RFID tag.**

### **5.2.2 Museum exhibition room**

As shown in the Figure 5.1, the following hardware are located in the museum exhibition rooms:

- **RFID reader** - the RFID reader is placed behind every artefact and it is responsible for sending out radio frequency signals to a configured reading range. Once the RFID tag that is carried by the visitor comes in the reading range, it gets connected to that particular reader for data transmission. For this study, the data transmitted consists of a tag ID, which is used to uniquely identify a museum visitor. Once the RFID tag is connected to the reader, the PSS starts counting the amount of time the tag remains connected to that particular reader. The PSS only stops counting when a tag is disconnected and enters a new reading range, or when the visitor has ended their museum visitation journey.



**Figure 5.3: 2.45 GHz Gain Adjustable Active RFID Reader.**

The Active 2.45 GHz Gain Adjustable RFID Reader/Receiver (Figure 5.3) that was used in this study has a reading range of up to 328 ft (100 m) and is able to be adjusted up to 5m through its gain value. The reader also has a built-in Omni-directional antenna that can read tag up to 100m from all direction. It also has a built in Power over Ethernet (PoE) that allows network cables to carry power (GOA RFID Inc, n.d).

- **Artefacts/galleries** - are objects that the museum exhibits. After a visitor is done with their museum visitation journey, their most interesting photo of artefact, description of that artefact, time spent by the visitor viewing that particular artefact and their photo that was taken at the reception are displayed on the screen in form of a souvenir card. The souvenir card is a surprise for the visitor, generated by the PSS. The visitor should decide whether or not they would like their souvenir to be printed out.
- **Server** - the database is being hosted on the server and all data are saved on the database. The generated souvenir card is displayed through a webpage that is being hosted on a XAMMP webserver.

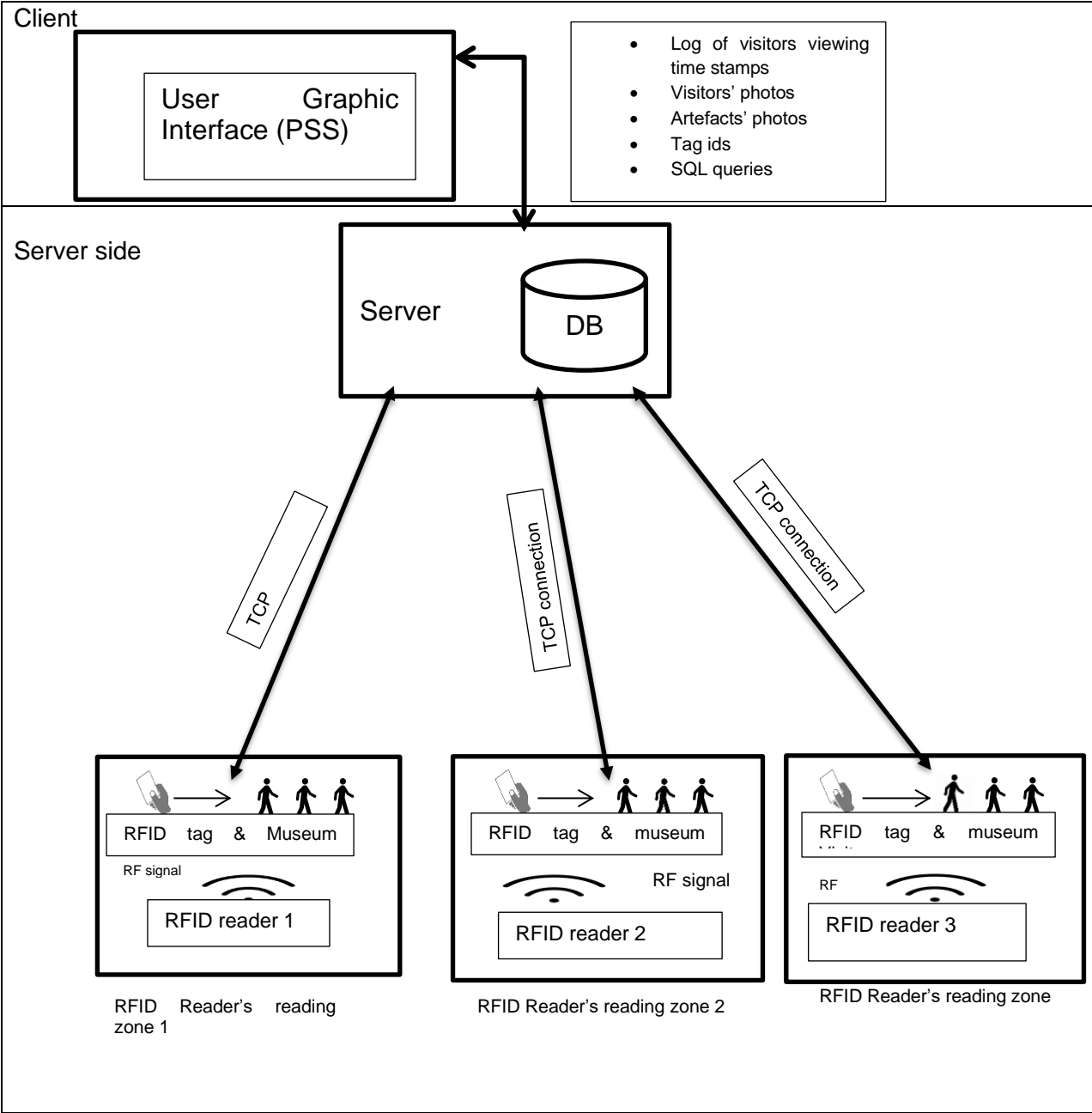
- **Wireless LAN** - all the devices are interconnected through a wireless router for data transportation. Wireless network is used to avoid cables from lying around the museum.

### 5.3 System architecture

Two-tiered architecture is employed as the architectural design for the PSS, which is a form of client-server architecture where the client communicates straight with the server and is mostly employed in the system with few users (Thakur, Client Server Architecture, n.d). The two-tier client/server architecture consists of a user computer and a server. The client-side application should be saved on the user computer. The server offers a platform for data-processing operations to various clients, which are divided among the two platforms: the client's side and the server's side of the tiers (Thakur, n.d).

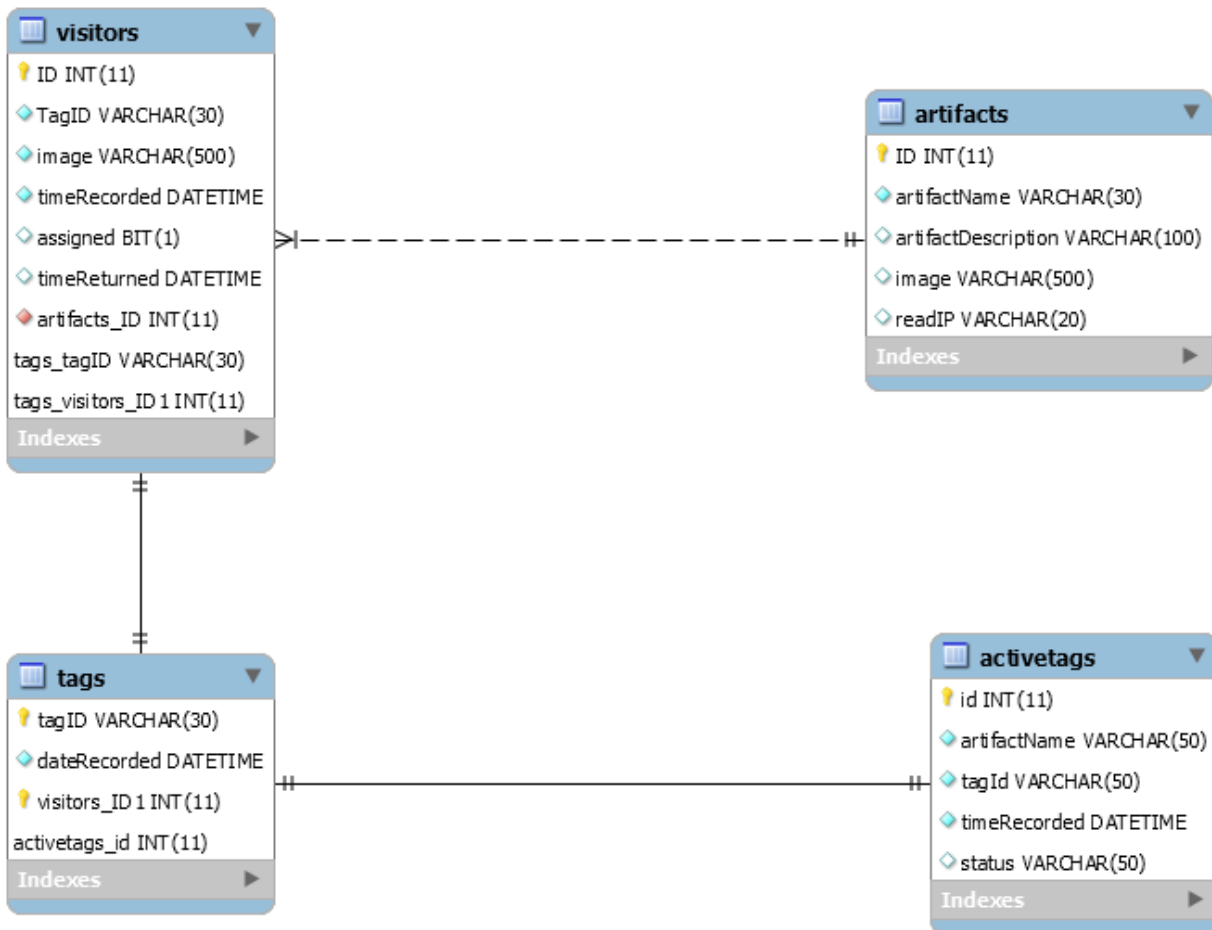
Figure 5.4 shows the system architecture for the PSS. The first tier consists of the user graphic interface of the PSS through the user graphic interface; users are able to communicate with the system through the PSS user graphic interface, which is responsible for communicating with the server through the wireless network and presents understandable information to the user. The client sends SQL queries to the server to either update the tables in the database or to retrieve data from the database to display it to the user.

In the second tier resides the MySQL database that is hosted by the server. The MySQL server offers database services to the first tier by receiving SQL queries from the first tier and sends back the requested data or adds data to the database. RFID readers are also located in the second tier. They communicate to the server using the Transport Communication Protocol (TCP) by means of a three-way handshake. The server and the reader had to create acknowledgement for the connection before they start sending actual data. Once the reader is connected to the server, real-time data from the tag connected to the reader are sent to the database until a session is over.



**Figure 5.4: System architecture for the Persuasive Souvenir System.**

## 5.4 Database design



**Figure 5.5: Logical Data Model for the Persuasive Souvenir System.**

Fig 5.5 illustrates the Logical Data Model for the PSS, which adds information to the conceptual model and it could be used to generate the actual physical database structure. This type of model presents information such as entities and their relationships, attributes of the entities, primary keys and foreign keys. Some of the database entities are described in detail below:

- **Artefacts** - It represents information about artefacts within the museum. One reader is associated to a single artefact and is identified by the assigned static IP address. The following information about the artefacts is captured and saved in the

database: the name and description of the artefacts, its image, as well as the IP address of the RFID reader assigned to the artefact.

- **Tags** - It represents information about the RFID tags that are supposed to be given to museum visitors for them to be tracked. The tag is also used to uniquely identify a visitor by the tag ID.
- **Visitors** - It represents information about museum visitors. The following information about the visitor should be captured: the visitor's assigned RFID tag ID, the visitor's image, and the time and date the visitor entered the museum.
- **Active tags** - It represents information about the all artefacts that a visitor viewed in a particular visiting journey. The following information should be recorded: tag ID, name of artefact, time recorded and the status (connected or disconnected).

## 5.6 Conclusion

This chapter presented the hardware setup overview for the proposed PSS, as well as the system architecture and the database design employed by the study, which is the two-tiered system architecture. The physical Logical Data Model for the Persuasive Souvenir System is also presented in Figure 5.5 to illustrate how data were organised in the MySQL database. The decision to use RFID as tracking technology in the current study is based on the results from literature review after reviewing studies that used different technologies to track individuals. The next chapter describes the steps and decisions made by the researcher in developing the PSS prototype for the study.

## **CHAPTER 6: SYSTEM /PROTOTYPE IMPLEMENTATION**

### **6.1 Introduction**

This chapter overviews and discusses all major technologies, development environment and tools used in the constructing of the Persuasive Souvenir System (PSS) prototype. Moreover, the chapter deliberates on the implementation of the database used for the study. Finally, the chapter emphasises the challenges and implementation issues that the researcher experienced during the development process.

### **6.2 Development environment**

#### **6.2.1 Software and hardware requirements**

The PSS runs on a typical window-based environment setup, which consists of a relational database system, RFID tools, server and user interface. The requirements for the software and hardware for the PSS are listed below:

##### **6.2.1.1 Software requirements**

- MySQL database
- Client Computer - Windows 10, 8.1, 8, 7
- Microsoft Visual Studio
- GAO RFID Connection Tool
- PHP
- Notepad++
- Browser
- XAMMP platform

##### **6.2.1.2 Hardware requirements**

- Desktop PC running 8/16GB memory, Core i5/i7 CPU, 500GB HDD
- GAO RFID Reader
- GAO RFID Tags

- Wireless Router
- LifeCam HD300 Camera

## **6.2.2 Development tools**

### **6.2.2.1 Persuasive Souvenir System**

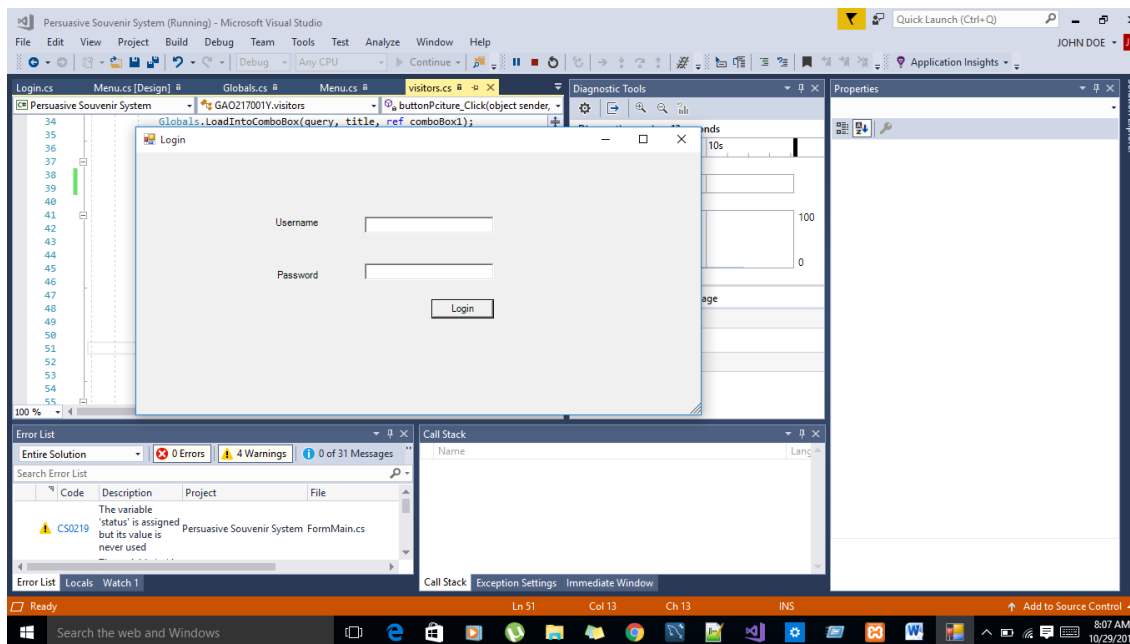
The prototype window-based application was developed in C# using Microsoft Visual Studio 2019 as the developing tool. C# is a modern objected oriented Programming language created by Microsoft within their .Net Framework, and it is part of the C/C++ family – more like Java, with enhanced feature like garbage collection (Srivastava, 2017). The researcher chose C# for the development of the PSS because due to the advanced knowledge of the language and it makes it easy to learn the extra features required. C# was created in 2002 after other languages have been in existence, which has created a chance for it to incorporate latest technologies in their class libraries and to fixed various problems experienced by developers when using languages like C++, C and Java.

C# has a typing help feature that allows the written program to have minimum errors. It also has ways to communicate with the network, as PSS requires information from the RFID tag to be sent through the network. Another advantage is that the .Net framework runtime environment enables different languages to communicate meaning that could be written with different components of the system in a different language. .Net class also allows the program to display input to the screen through its runtime environment (Reges , 2002).

### **6.2.2.2 Graphical User Interface**

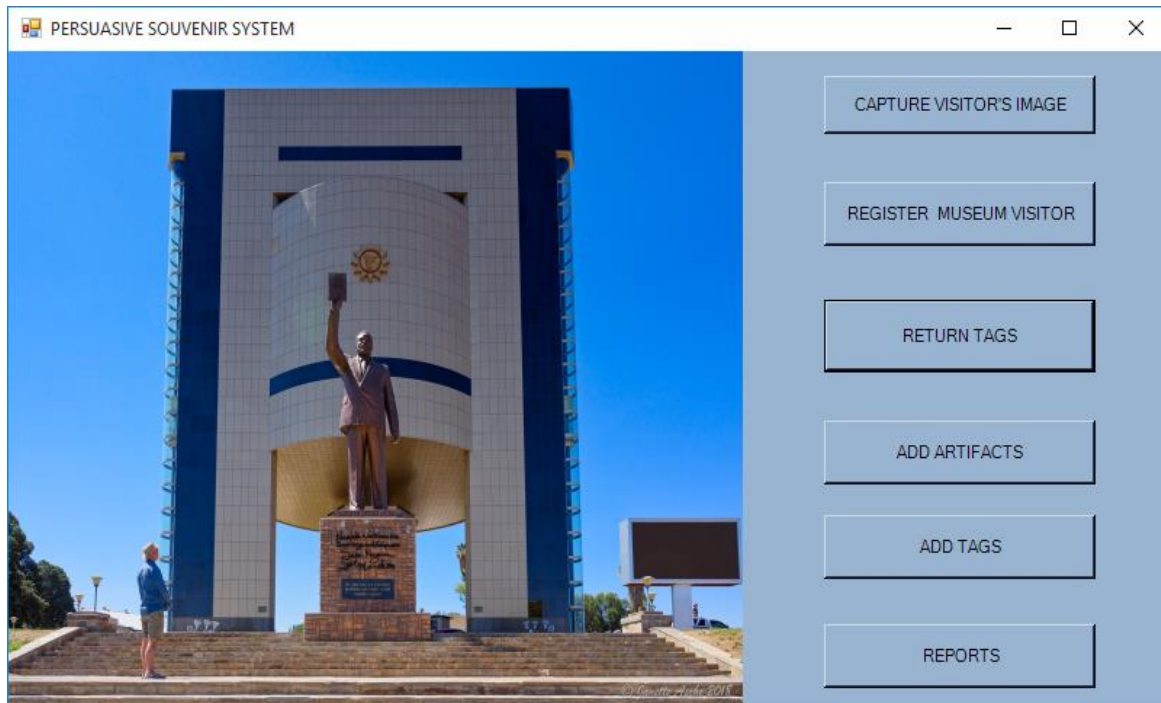
The system user interface (GUI) is one of the important features of the system, as it assists clients to use the system efficiently and effectively. The developer should ensure that the user interface is user friendly for the user to be able to navigate and communicate with the computer easily and accurately (Jitnupong & Jirachiefpattana, 2018).The

graphical user interface for the PSS was created using Window forms (Figure 6.1). The Window form graphical User interface class comes with the Microsoft .Net Framework.



**Figure 6.1 : PSS Graphic User Interface: Login.**

The landing page for the PSS is the login page that requires users to fill in their login details. Once successfully logged in, the user is taken to the menu page (Figure 6.2). All users will be provided with their login details that are generated and saved in the MySQL database.



**Figure 6.2: PSS Main menu**

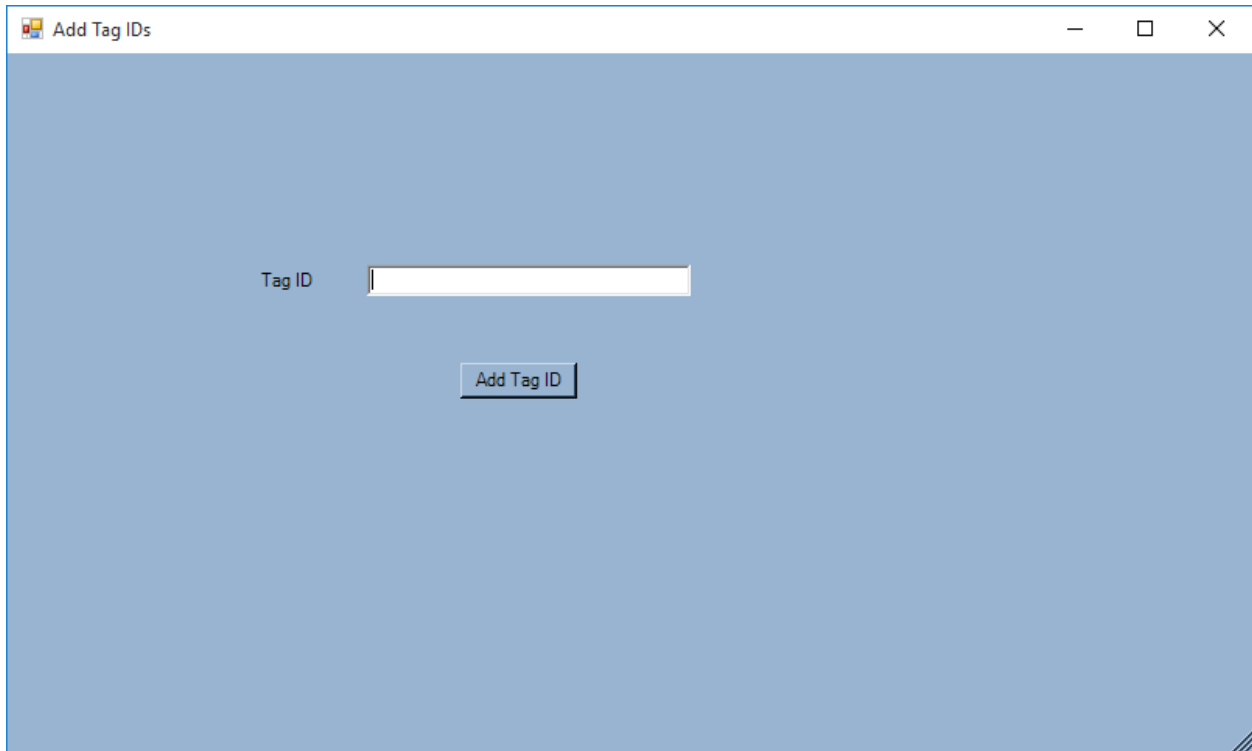
The main menu page is a platform where the user communicates with the PSS. The user could add information about artefacts by clicking on the 'add artefacts' button that then directs the user to the 'add artefact' form (Figure 6.3). The user is required to enter the following information: the name of artefact, description of artefacts, the static IP address assigned to the RFID reader behind the artefact and the image of the artefacts. The information is then sent to the table in the MySQL database.

The screenshot shows a web application window titled "Add Artifact". The window has a light blue background and contains the following elements:

- Artifact Name:** A single-line text input field.
- Description:** A multi-line text area.
- Reader IP Address:** A single-line text input field.
- Image:** A button labeled "select Pic".
- Submit Button:** A button labeled "Add an artifact" located at the bottom center of the form.

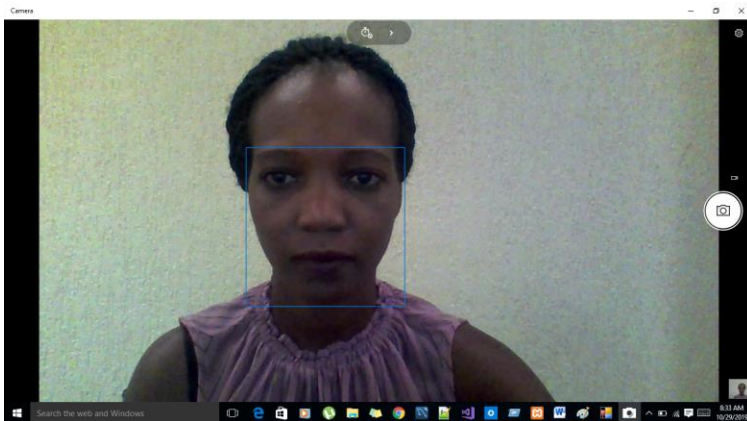
**Figure 6.3: Add artefact form**

The user could also use the main menu to add tag IDs from RFID tags by clicking on the 'add tag' button. The button takes users to the 'Add Tag ID' form, where they are required to enter the tag ID for that particular RFID tag. The information is sent to the database by clicking on the 'add tag' ID.



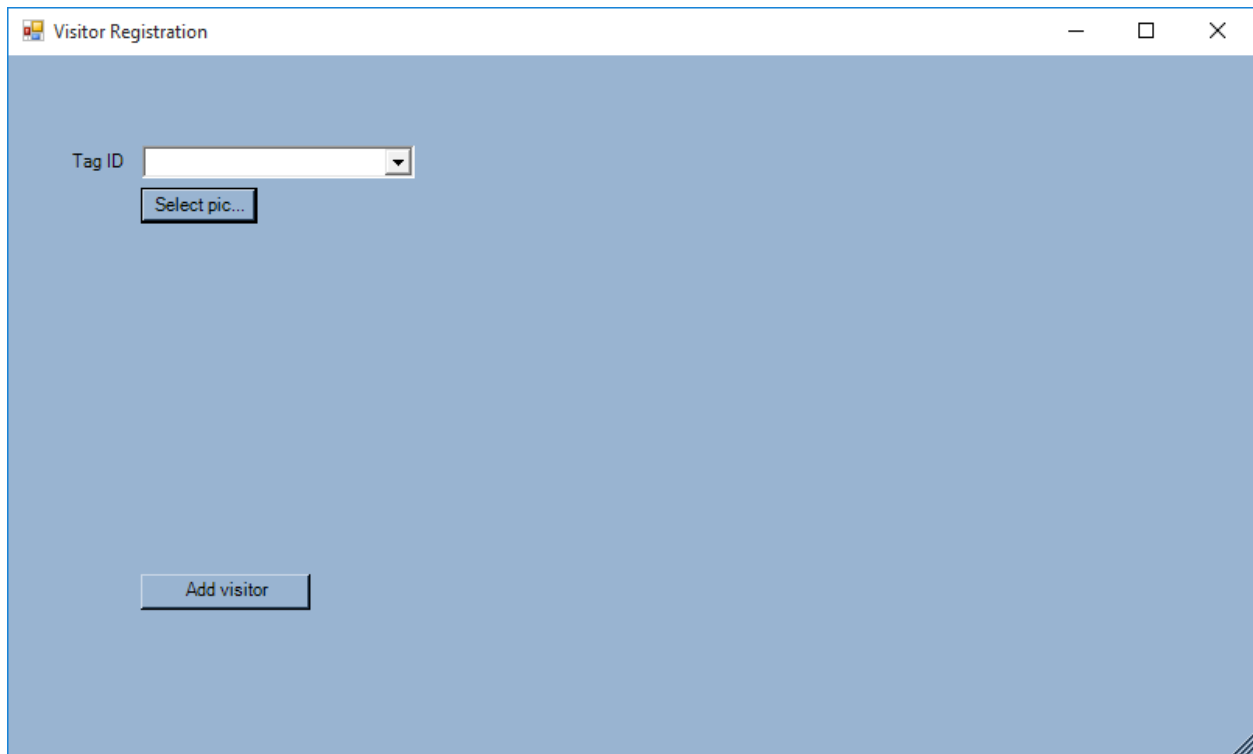
**Figure 6.4: Add Tag ID form**

In order for the museum visitor to be traceable within the museum, the user is required to capture the visitor's information. The first information captured is the image of the visitor with their consent. If the visitor does not consent, a default picture of the Namibian flag will be used. For the image to be captured, the user is required to click on 'capture visitor's image' button that leads to the LifeCam HD300 Camera preview (Figure 6.5) for the user to take the picture. The image is saved to the local folder.



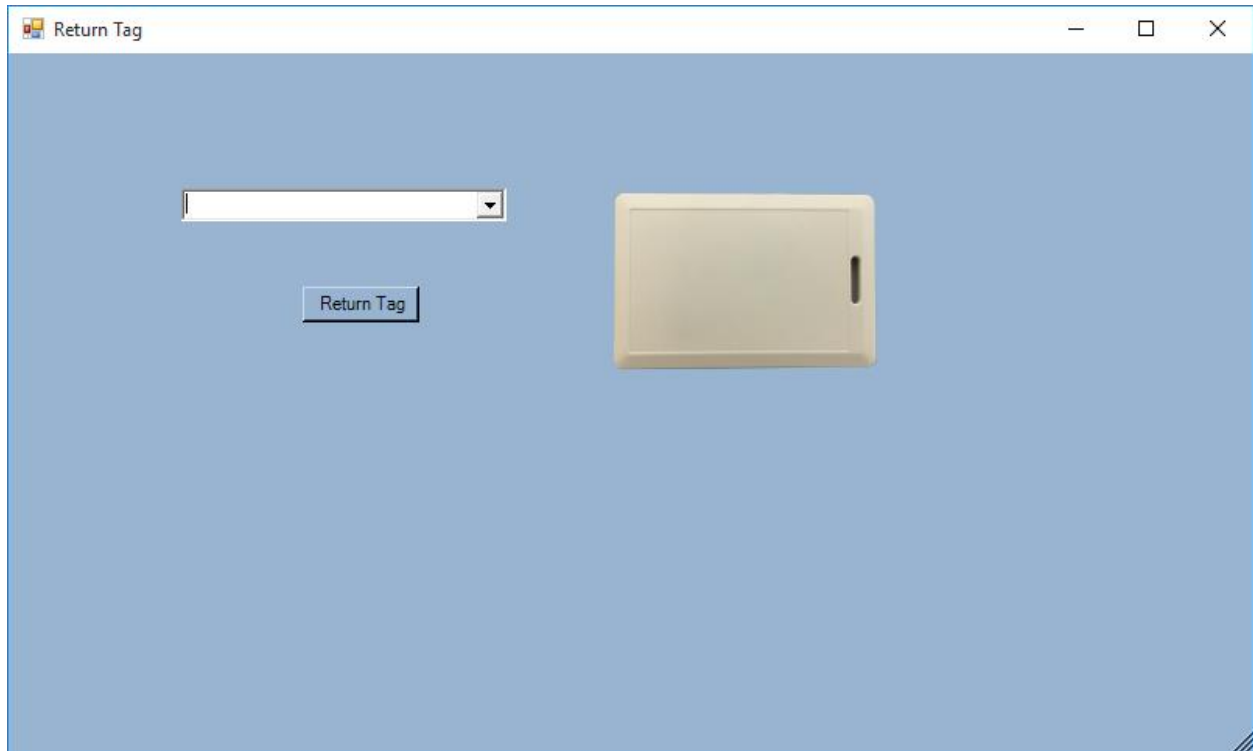
**Figure 6.5: LifeCam HD300 Camera preview.**

The user is then required to register a visitor by using the visitor registration form (Figure 6.6). The following information should be captured: tag ID assigned to the visitor, time and date, and his photo or Namibian flag photo. The information is then sent to the database. Once the tag is assigned to the visitor, the information is updated in the database that the particular tag is unavailable. The unavailable tag cannot be assigned to another visitor.

The image shows a software window titled "Visitor Registration". The window has a light blue background. In the upper left area, there is a label "Tag ID" followed by a white dropdown menu. Below the dropdown menu is a button labeled "Select pic...". In the lower left area, there is a button labeled "Add visitor". The window has standard Windows-style window controls (minimize, maximize, close) in the top right corner.

**Figure 6.6: Visitor registration form**

Once the visitor is done with their visitation journey, they are required to return the tag. The user uses the return tag form (Figure 6.8) to capture the information. Once the tag is returned, the database updates that the tag ID is available to be used again. The report about the visitor represented by that tag is then generated.



**Figure 6.8: Return tag form**

### **6.2.2.3 Reporting or generation of the persuasive souvenir**

Generation of a souvenir card containing two components: (1) a visitor's image and (2) the image of the artefact that the visitor has spent focusing on as, well as the text description of that artefact and the time spent was done through a web application using PHP scripting language under the XAMMP platform. XAMMP stands Cross-Platform (X), Apache (A), MySQL (M), PHP (P) and Perl (P). This study used XAMMP because it is an open source platform, it speeds up the testing session, and it is local hosted (Mikoluk, Kasia;, 2013).

In order to generate the souvenir, the following steps were taken:

Firstly, a query was developed to select all the unique returned tag numbers from current date from the visitor's table:

```
$str = "$today";
```

```
$query = "SELECT distinct(TagID) as TagID FROM visitors where assigned=0 and  
timeRecorded >= '$str' ";
```

The extracted data is then ordered in a descending manner: the time the tag was returned, using the query below: *SELECT \* FROM rfid.visitors where TagID='\$tagID' and assigned=0 order by timeReturned Desc.*

Then, according to the selected tag IDs, names of artefacts and time recorded between the time the visitor registered and the time the visitor returned the tag are extracted from the database using the following SQL query:

```
SELECT distinct(artefactName) as artefactName FROM activetags where tagID='$tagID'  
and timeRecorded between '$timeRecorded' and '$timeReturned' order by  
timeRecorded"
```

After that, the time the tag is connected to the reader associated with that particular artefact is extracted as the recorded time and the time the tag was disconnected from that particular tag by selecting the time at the first row and the time at the last row. Furthermore, the time taken by the visitor to view each artefact is calculated using the `diff()` function. The `diff()` function is used to find the difference between two dates, and it is displayed in minutes. The codes responsible are as follows:











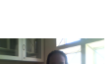

```
SELECT activetags.*, artefacts.image as image , artefacts.artefactdescription as  
description FROM (activetags left join artefacts on  
artefacts.artefactName=activetags.artefactName)  
where tagID='$tagID' and timeRecorded between '$timeRecorded' and '$timeReturned'  
and activetags.artefactName='$artefactName' order by timeRecorded";  
$result4 = mysqli_query($link, $query4) or die(mysqli_error($link).";<br /> ".$query4);  
    $num_rows4 = mysqli_num_rows($result4);  
    if ($num_rows4)  
    {  
        mysqli_data_seek($result4, 0);  
        $obj_artefacts_r1 = mysqli_fetch_object($result4);
```

```

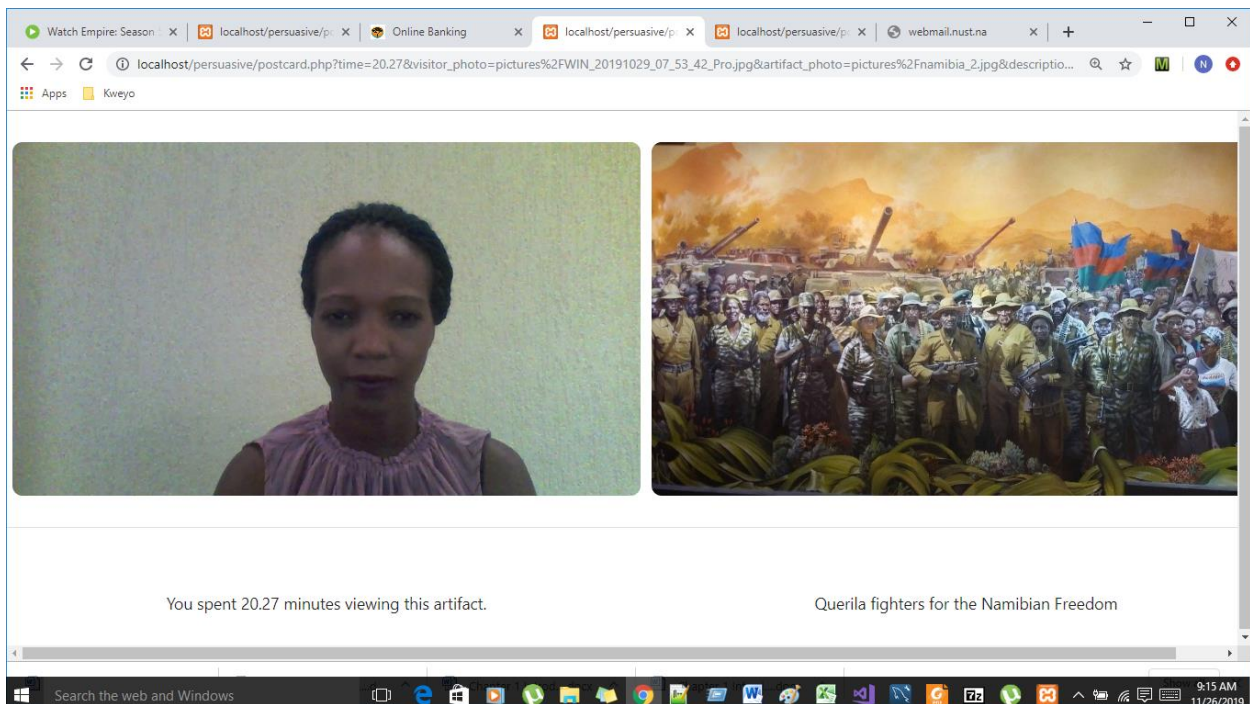
mysql_data_seek($result4, $num_rows4-1);
$obj_artefacts_r2 = mysql_fetch_object($result4);
$recorded_time1 = $obj_artefacts_r1->timeRecorded;
$recorded_time2 = $obj_artefacts_r2->timeRecorded;
$description = $obj_artefacts_r2->description;
// echo $recorded_time1."---".$recorded_time2."<br />";
$start_date = new DateTime($recorded_time1);
$since_start=$start_date->diff(new
DateTime($recorded_time2));
$minutes = $since_start->days * 24 * 60;
$minutes += $since_start->h * 60;
$minutes += $since_start->i;
$minutes += $since_start->s/60;
$minutes = round($minutes, 2);
}

```

Finally, the artefacts and their viewed time for a particular visitor (Figure 6.9) are displayed and the souvenir is then generated by selecting the longest viewed artefacts, the time spent, description of the artefact and the photo of the visitor. The souvenir card is displayed on a second screen facing the visitor.

Tags			
No.	Visitor	Artifacts	Action
4300000000016695		Sam Nujoma  Time spent: 1.83 Minutes	<a href="#">View Souvenir</a>
		Ndinelago  Time spent: 3.98 Minutes	
4300000000016699		Sam Nujoma  Time spent: 0 Minutes	<a href="#">View Souvenir</a>
		Soldiers  Time spent: 1.07 Minutes	
4300000000016709			<a href="#">View Souvenir</a>
4300000000016701		Soldiers  Time spent: 20.27 Minutes	<a href="#">View Souvenir</a>
		Sam Nujoma  Time spent: 1.43 Minutes	
		Soldiers  Time spent: 19.33 Minutes	

**Figure 6.9: Museum visitors' visiting journey report**



Watch Empire: Season x localhost/persuasive/p/ x Online Banking x localhost/persuasive/p/ x localhost/persuasive/p/ x webmail.nust.na x +

localhost/persuasive/postcard.php?time=20.27&visitor\_photo=pictures%2FWIN\_20191029\_07\_53\_42\_Pro.jpg&artifact\_photo=pictures%2Fnamibia\_2.jpg&descriptio...

Apps Kweyo

You spent 20.27 minutes viewing this artifact.

Querila fighters for the Namibian Freedom

9:15 AM 11/26/2019

**Figure 6.10 : Persuasive Souvenir**

#### 6.2.2.4 RFID technology communication interface

The GOA RFID reader comes with two interfaces: the first one is a Radio Frequency (RF) interface that allows for the tag and the reader to communicate within their reading range. Once the tag is connected to the reader through the RF Interface, the reader receives information from the tag and extracts the tag ID through this interface. The second interface allows the reader to communicate with the server over the network, using the transport communication protocol. To enable the communication to take place between the tag and the reader, as well as between the reader and the server, the following RFID Reader Network setting (Fig 6.11) should be done through an RS-232 serial communication cable using the **GAO 217001Y Config Tool** that is installed from the **GAORFID217001Setup.msi**. The **GAORFID217001Setup.msi** software was developed by GAO RFID Inc. Company as part of the RFID Hardware that the researcher purchased for the study.

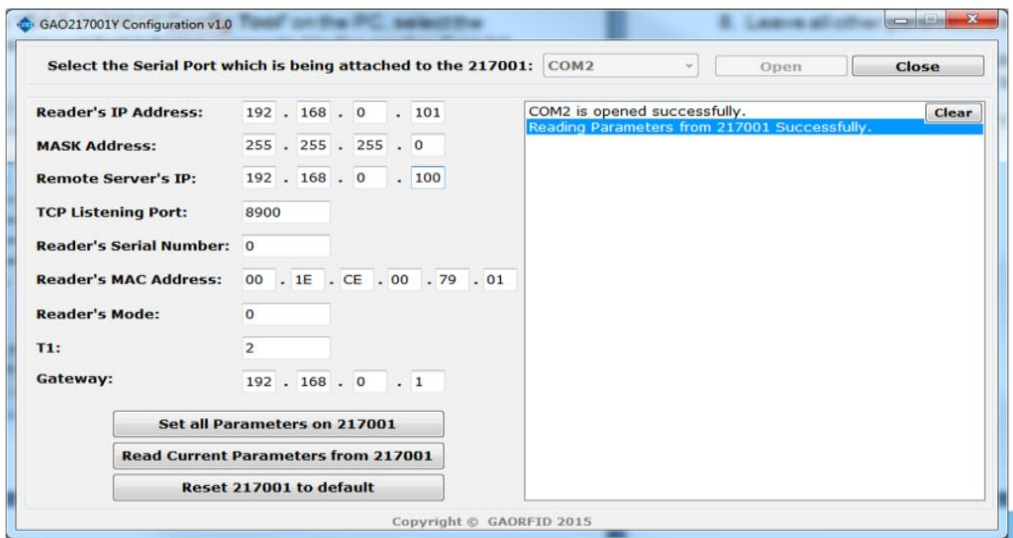


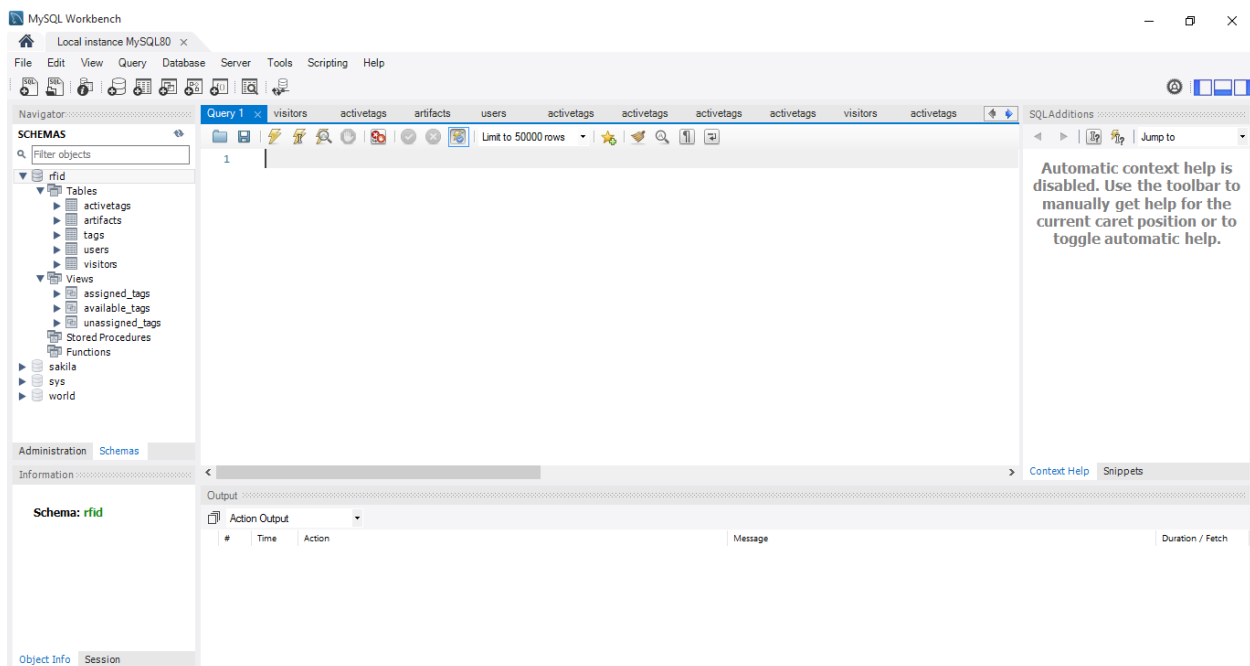
Figure 6.11: RFID reader connection settings

### 6.3 Database implementation

The database for this study is implemented and managed through MySQL Workbench 8.0 database (Figure 6.12) as the Database Management System (DBMS). The MySQL work bench was selected because it is free and it used for development and testing

purposes. For the purpose of deployment, museums can opt for different database like SQL Server express edition that is equally free. MySQL work bench enabled the researcher to connect to and manage the SQL Server from a graphical interface instead of doing it through the command line.

The Structured Query Language (SQL) was used to communicate with the database on the server by sending data captured by the PSS and RFID data from the reader, and to access data in the database. The researcher preferred using MySQL work bench relational database because of its popularity and user friendliness. The PSS is run through a .Net Environment, and coupling these two tools together works well. Additionally, the use of structured data ensures there is few or no redundancy of data.



**Figure 6.12: MySQL Workbench 8.0**

MySQL Workbench database is connected to PSS through a custom-made API (Application programming interface). Firstly, the researcher created a database called “rfid” within which the required tables were created. For better management and retrieving of data, there was a need to create some database views. A database view can be defined as an item that is found in a database and only distinct by an SQL query or computer-

generated tables that are not physically presented in the database but only notated by a query (Kris, n.d).

## **6.4 Challenges**

- Time consuming - It was challenging to choose the right readers and tags that are suitable for the prototype developed in the study. The researcher also found it challenging to find a supplier for the RFID hardware. Since there is no local supplier, the researcher had to ensure the right RFID equipment: tags and readers were carefully chosen to avoid mistakes.
- Reading range - The reading range for readers for the study is only adjustable up to 5 meters. This requires artefacts to be placed at least 5 m far from each other to ensure a 5 meter reading zone from all sides should be created where readers could connect to a tag carried by the visitor. Unfortunately, the artefacts in the museums are not placed 5 meters apart.
- Inconsistency of tag data from the reader - In some cases, the operation of the system is interrupted by the inconsistent state of tag data because it results in the tag ID not being able to be extracted at the moment.
- Delays of data - Visitors are being tracked in real-time; thus, there were often delays in receiving data from readers and sending it to the server. This also affects the performance of the system.

## **6.5 Conclusion**

The PSS was developed using C# as a programming language. The graphical user interface for the PSS was created using Window forms. To display the souvenir card, the PHP was used to create a web page. The souvenir card and the report are displayed in a form of web page. A database was implemented and managed for this study, through the MySQL Workbench 8.0 database. The next chapter presents the testing plan for the PSS prototype, as well as the findings or testing results

## **CHAPTER 7: PROTOTYPE TESTING**

### **7.1 Introduction**

According to Sarwar et al. (2013), testing are procedures that ensure the created system talks to the established requirements and works without faults after deployment. Testing plays a crucial role in the computer program creation process, and nearly 80% of the developed systems do not succeed because of poor testing procedures (Gupta, 2010). The main objective of this study was to develop a persuasive souvenir system (PSS) for Namibian museums, using RFID technology that can be used to track the amount of time visitors spent focusing on artefacts in the museum. Based on the PSS, visitors were presented with a souvenir card with two components: (1) a visitor's image and (2) the image of the artefacts the visitor has spent the most time focusing on, as well as the text description of that artefact.

The souvenir card is meant to act as a persuasive component to attract more visitors to the museum or to encourage existing visitors to revisit the museums. Thus, for the development of the PSS, functional and non-functional requirements were generated from the information gathered through an online questionnaire, which was distributed among 40 Windhoek residents, through interaction with the museum staffs, researcher visits to Independence Memorial Museum and input from the research supervisor and computer science staff members at the Namibia University of Science and Technology. The proposed prototype was then tested to ensure it meets its proposed expectation and was able to produce the required output according to the proposed requirements. This chapter outlines the testing procedures adopted for the study to test functional and non-functional requirements for the proposed system.

### **7.2 Testing procedures of the system**

During the development of the prototype, unit testing was done on every component of the system, using a white box testing method. White box testing methods ensured that each component is working according to the required functions, evaluating how the internal structures of the system are working. White box testing is usually done by

members of the development team of the system, who understand the design and codes of the system (Software Testing Fundamentals, n.d). Non-functional and functional tests are discussed in the following sections below:

### **7.3 Functional requirements**

The aim of the functional testing is to test the created prototype against the specified requirements that were defined in Chapter 4. During the functional requirement testing, the system's functions are evaluated by entering data into the system and analysing the result against the specified requirements. The black box testing procedure was employed during this testing phase to achieve the testing objectives; it is carried out by testers who lack knowledge of the interior structure of the system being evaluated (Software Testing Fundamentals, n.d). The PSS prototype was tested using real-life test cases, and the results were evaluated for correctness according to the defined requirements.

### **7.4 Non-Functional requirements**

Non-Functional requirements describe the traits of the system (how the system must function). According to Chung (n.d), non-functional requirements are not easy to test; hence, they are mostly evaluated based on user's perspectives (Sanjay, 2016). The testing is meant to check whether the non-functional requirements defined in Chapter 4 are met. The performance, security and usability aspects of the PSS were tested.

### **7.5 Test procedures**

#### **7.5.1 Usability testing**

Usability testing is carried out by allowing real users to use the application to carry out an envisioned task. The users should give feedback about whether or not they are satisfied with the application. They are also tasked to identify errors within the application and recommend areas for improvements. The usability test ensures the user can use the

application to carry out the specified task without any difficulty. The user interface is also judged at this stage (Rubin & Chisnell, 2008).

The users involved in these tests are not part of the development team. The selection was done to ensure that black box testing procedure is employed. Every button was checked to verify all the buttons are operating. The testing of the PSS prototype was conducted by 3 users, who are tour guide personnel from Independence Memorial Museum. The users had no prior training on the PSS prototype; they only had a brief introduction of the use and purpose of the system. The users evaluated the prototype by using real world use cases that were written with the functional requirements, described in Chapter 4 as the basis, and they are listed in a sheet (Table 7.1 to 7.4).

The users executed the tasks listed in the test cases sheets, using PSS and analysed the results from the PSS. The last row of the test cases sheets represents the result from the tests. The system functionality was only considered passed the test when all three users were pleased by the results. Users were required to answer the post-testing questions handed to them for interface testing (Appendix A). They were also required to comment on the PSS and provide any recommendation. Table 7.1 represents the testing cases for then the log in functionality to verify whether the user could use the PSS interface to log in to the main page of the PSS. Once logged in, the user was further able to use the PSS prototype. The testing result indicated that the PSS has passed the test for this login functionality.

**Table 7.1: Task 1 <Login to the PSS>**

Goal/output	To test if the PSS interface is able to perform the task. <ul style="list-style-type: none"> <li>• Login</li> </ul>
Assumptions	An account for this particular user has already been created.
Inputs	Username: admin Password: admin
Steps	<ol style="list-style-type: none"> <li>1. Open PSS prototype</li> <li>2. type in username</li> <li>3. type in password</li> <li>4. Click on login button</li> </ol>
Pass/fail	Pass

Table 7.2 presents the testing cases for the registering museum visitor’s functionality. The testing is necessary to verify whether the user is able to use the PSS interface to register a museum visitor and assign an RFID tag. The testing result indicated that the PSS has passed the test for the ‘register a visitor’ functionality.

**Table 7.2: Task 2<Register a visitor>**

Goal/output	To test if the PSS interface is able to perform the task. <ul style="list-style-type: none"> <li>• Register a visitor</li> </ul>
Assumptions	The user has logged in to PSS
Inputs	Picture file RFID Tag ID
Steps	<ol style="list-style-type: none"> <li>1. Open PSS prototype</li> <li>2. Click on capture visitor’s image button</li> <li>3. Click to Capture Visitor image</li> <li>4. Click on Register visitor button</li> </ol>

	<ol style="list-style-type: none"> <li>5. Select an RFID tag tag ID written on the selected tag and give the tag to the visitor.</li> <li>6. Click on select picture</li> <li>7. Browse for the visitor pictured that was captured earlier.</li> <li>8. Click on the button add visitor</li> </ol>
Pass/fail	Pass

Table 7.3 presents the testing cases for the return tag functionality. The testing is necessary to verify if the user is able to use the PSS interface to return the RFID tag. Once the tag is returned, the PSS re-avails it. Returning the tag indicates the end of the museum visitation journey. The available tags can be reused by any other visitor upon registration. The testing result indicated that the PSS has passed the test for the 'return tag' functionality.

**Table 7-3: Task 3<Return Tag>**

Goal/output	To test if the PSS interface is capable of listing all the assigned tag to museum visitors and remove it from the assigned tag list after the tag has been returned.
Assumptions	<p>An account for this particular user has already been created.</p> <p>A museum visitor has been registered.</p> <p>The museum visitor is done with their visitation journey and returning the tag</p>
Inputs	Tag ID
Steps	<ol style="list-style-type: none"> <li>5. Open PSS prototype</li> <li>6. Click on button return tag</li> </ol>

	<ul style="list-style-type: none"> <li>7. Select the tag ID</li> <li>8. Click on log in button</li> </ul>
Pass/fail	Pass

Table 7.4 represents the testing cases for generating a souvenir card functionality. The testing is necessary to verify if the user could use the PSS interface to generate a souvenir card for the visitor. The souvenir card must contain two components: (1) a visitor’s image and (2) the image of the artefacts the visitor had spent more time focusing on, as well as the text description of that artefact. The visitor should decide whether or not their souvenir card should be printed at a certain fee. The testing result indicated that the PSS has passed the test for the ‘generate souvenir card’ functionality. However, users suggested that the souvenir card should be improved. The improvement of the souvenir includes adding more decorative features to make it look more attractive. Users advised that graphic designers are consulted to help with designing a more attractive souvenir.

**Table 7.4: Task 4<Generate souvenir>**

Goal/output	To test if the PSS interface is able to perform the task. <ul style="list-style-type: none"><li>• Generate souvenir card</li></ul>
Assumptions	An account for this particular user has already been created. The user has logged in to PSS. A museum visitor has been registered. The museum visitor is done with his/her visitation journey. The visitor has returned the RFID tag.
Inputs	None
Steps	<ol style="list-style-type: none"><li>1. Open PSS prototype</li><li>2. Click on Reporting button</li><li>3. A webpage will open up. The webpage consists of the list of the latest generated souvenirs.</li><li>4. The souvenir for the current visitor will be first on the list. The souvenir is identified by the RFID tag ID that was returned by the current visitor.</li><li>5. Click on 'open souvenir' link. The souvenirs will be displayed.</li><li>6. Show the souvenir to the visitor by sharing it on the second screen facing the visitor.</li><li>7. Observe the visitor's reaction.</li><li>8. Print out the souvenir.</li></ol>
Pass/fail	Pass

Other tasks that were also tested and verified are adding a tag and artefacts to the database. Results for these tasks were also satisfying.

### **7.5.2 Performance testing**

Performance testing is meant to evaluate how long the system takes to react to the user requests, as well as how it reacts under a certain unplanned load (Salas, n.d). To test the performance of the PSS, the following response times from the PSS were measured:

- Response time to load data from MySQL database.
- Number of visitors that can be tracked by RFID Technology at once.
- Response time of the system to connect to the next RFID reader and extract the position of the visitor immediately after they have moved to the next artefact.

The read () method to load data from the MySQL database generates data on a click. The process to load data from the database is fast enough, increasing the performance of the prototype. The Prototype can only allow 100 visitors to be connected to one of the RFID readers and be tracked at once. Currently, this is not an issue because it is very rare to find more than 100 visitors viewing the same artefact at the same time, but if the situation changes, provision will be made to deploy more powerful readers. Furthermore, there is delay in response time of the system to connect to the next RFID reader and extract the position of the visitor immediately after they have moved to the next artefact. The delay in response time was less than 30 seconds; thus, it did not affect the result but future improvements will be made.

### **7.5.3 Security testing**

Security testing is meant to evaluate if the created program has any weaknesses, and it is protected from any unauthorised access to the system and data. It also helps in identifying any other safety issues that may cause harm to the system. The security testing is important, as it evaluates and identifies the security loophole in the system. It also helps to identify system security features that need improvement (Gurr99, n.d). To ensure that PSS was free from security risks, authentication tests were performed on the PSS

prototype. Users were given a chance to test the login and log out functionalities. They also tested for the default logins by leaving the password blank.

The testing results indicated that the PSS has passed the test for authentication tests. However, there is a need for a full security test that will be done in the future and necessary changes will be made to the prototype to improve the security features of the PSS Prototype. The following security decisions were also made to ensure protection of the system and user data:

- The PSS is only collecting visitor's images, without additional information to individually identify them. This was made to ensure that visitor privacy to share their information is protected and that there is no track of identification. This encourages visitors to be more comfortable with using the prototype.
- Data is not accessible outside the museum.
- MySQL security policy setup for the PSS only allows the system administrator to make changes to the database structure. Other users could also be granted such privileges on request.
- To ensure that data is accessible from unwanted or untrusted locations, each user is only allowed to access the database with the local network address that belongs to the museum.

#### **7.5.4 Acceptance testing**

Acceptance testing is the final stage of the application testing against the specified requirements. The test is carried out by the end users, who test for the accuracy and readiness of the system for use. During the acceptance testing, users should approve whether or not the system is suitable for the defined purpose (Goel & Gupta, 2004). End users' testing results showed that the PSS has passed all the test cases that were carried out. Thus, the main objective to develop a persuasive souvenir system (PSS) for Namibian museums using RFID technology was achieved. The system was used to track the amount of time visitors have spent focusing on each artefact of the museum. Based on the PSS, visitors were presented with a souvenir card containing two components: (1)

a visitor's image and (2) the image of the artefacts they spent more time focusing on, with a text description of that artefact. The implementations of these functionalities were also successful. Furthermore, users have proposed that the final output, which is a souvenir card, should be improved. There are also some performance faults detected, which was the delayed response time of the system to connect to the RFID reader and extract the position of the visitor immediately after they moved to the next artefact.

The persuasive component of the PSS prototype was not tested because of the limited time trial, and taking into account that there is a possibility of visitors taking longer time to decide whether they should visit the museum again or not again, but an agreement had been reached and plans are in place with the Museums Association of Namibia to setup the PSS prototype in the Independence Memorial Museum. The museum will start using the PSS to test whether it is indeed able to convince visitors to revisit, or whether the souvenir will be able to convince new visitors to start coming to the museum. The questionnaire that was carried out for the study included questions that are meant to receive an early reaction to the PSS. All respondents indicated they will be happy and surprised to receive a souvenir card.

## **7.6 General impressions and comments about the system prototype**

All the tour guides personnel that took part in the PSS prototype testing process were very excited about the PSS prototype. They said the museum is in need of such systems. They were fast to understand the purpose of the prototype, emphasising that the system will be a convenient tool to bring some excitement to the museum. After they performed the testing, tour guide personnel stated that the prototype was easy to use and they can already remember the steps needed to accomplish the task. Management of the museum, including the director and chief curator, were fascinated by the PSS prototype; they are also aware of the low turnout problem to the museums. Hence, they are exploring practical solutions that will help to solve and boost up the number of visitors to Namibian museums. Low turn is seen mostly among the Namibian citizens compared to foreigners.

The tour guide personnel suggested that the final product, the souvenir card, should be improved to make it more attractive.

## **7.7 Conclusion**

The testing phase concluded that the prototype functions well; however, the overall output (souvenir card) should be improved. The improvement of the souvenir includes adding decorative features to make it look attractive. Users advised that consultation with graphic designers should be made to help with designing a more attractive souvenir card. Furthermore, some performance faults were found and need to be addressed as soon as possible. The performance fault detected was the delay in response time of the system to connect to the next RFID reader and extract the position of the visitor immediately after they have moved to the next artefact. The delay in response time was found to equal or less than a second; therefore, it will not affect the result extremely, but future improvements will be made. The next chapter presents the summary and conclusion of study, emphasising on suggestions and directions for future research.

## **CHAPTER 8: CONCLUSION AND FUTURE WORK**

### **8.1 Introduction**

This final chapter summarises and concludes the study. It also outlines the achievements and outcomes of the study, based on the objectives of the presented in Chapter 1. The chapter then makes recommendations for possible future research.

### **8.2 Outcomes of the research**

The main objective of the study was successfully achieved, which was to develop a persuasive souvenir system (PSS) for Namibian museums, with the integration of RFID technology, using the Independence Memorial Museum as a case study. A system-based PSS was developed to track the amount of time visitors have spent focusing on each of artefacts of a museum. Based on the PSS, visitors will be presented with souvenir card containing two components: (1) a visitor's image and (2) the image of the artefact that the visitor has spent more time focusing on, with a text description of that artefact. The requirements for the system are well defined in Chapter 4 and they were evaluated in Chapter 7. The system is still in a prototyping phase; hence, any suggestion for enhancement and improvement could be easily integrated following the design approach that was utilised.

The first sub-objective was to establish how artefacts are exhibited to visitors in Namibian museums. This sub-objective has been described and highlighted in Chapter 3. The researcher made several visits to the Independence Memorial Museum and Owela museum for observation on how artefacts are exhibited to visitors. The findings contributed to the decisions on design in the development of the PSS.

The second sub-objective was to investigate the factors that could impact the use of the persuasive souvenir system in Namibian museums. The finding of this study suggests that the following factors could impact the use of PSS in Namibian museums:

- Lack of funds – funding at museums is currently very limited. Namibian museums do not generate any income; they depend on donations and government funds. However, according to museum curators, the government hesitates to fund the museums, under the perception that museums are not being utilised by the locals (Curators I. M., 2019). Funds are required for the successful implementation of the proposed PSS, such as to purchase IT resources for the PSS.
- Museum marketing strategy – currently, museums focus on the traditional forms of advertising by placing adverts in newspapers or pamphlets. With the growth of ICT and social media, museums are required to change this outdated form of marketing to enable them to have an audience to communicate to.
- Dedicated IT personnel – Museums should have dedicated personnel to manage the proposed PSS, who will also be required to assist the end users with PSS technical issues and installations.

The third sub-objective was to design a prototype based on RFID and investigate how a computer-based solution could positively influence the number of visitors to museums in Namibia. This sub-objective was partially achieved: a Persuasive Souvenir System was developed and tested for its functional and non-functional requirements. However, due to limited time trial, and taking into account that there is a possibility of visitors taking longer time to decide whether they should visit the museum again or not, the prototype was not tested on how it could positively influence the number of visitors to museums in Namibia. Therefore, an agreement had been reached and plans are in place with the Museums Association of Namibia to setup the PSS prototype in the National Memorial Museums to start using it and test whether the system is indeed able to convince visitors to revisits or the souvenir will be able to convince new visitors to start coming to the museum

### **8.3 Future work for the research**

The PSS developed in this study is still in the prototyping stage; hence, several improvements to the system have been suggested during the evaluation of PSS. The suggested improvements are part of future works that should be carried out to continue this study. The following challenges and opportunities can be considered as future works:

- The souvenir card can be further improved to make it more attractive. According to the museum tour guides who were part of the testing team, the souvenir card needs to be decorated. They suggested that graphic designers should be consulted to help with the proposed task.
- The persuasive component of the PSS prototype can be evaluated for its capability to convince visitors to revisit or the souvenir will be able to convince new visitors to start coming to the museum.
- Improvement to enhance the response time of the system to connect to the next RFID reader and extract the position of the visitor immediately after they have moved to the next artefact.
- The PSS could be evaluated for full security issues, so that necessary changes can be made to the prototype to improve its security features.
- More reports can be generated from the MySQL database; for example, the report of the overall time spent by visitors viewing each artefact in the museum for a specific time. The specific time could be a couple of months or a year.
- The delete functionality could be added to the PSS to be able to remove information from the database.
- The edit functionality could be added to the PSS to be able to edit information in the database.
- Face recognition technology could be integrated for verification if the visitor is indeed looking at the artefact or elsewhere.
- More reports could be generated to find patterns if some visitors are just escorting others by following them around and not real viewing artefacts.

Furthermore, the work presented in the current study can create possibilities for future researchers to use the work done or results to enhance this study, or to find new solutions regarding the low turnout to Namibian museums.

## **8.4 Conclusion**

The main objective of this study was to develop a persuasive souvenir system (PSS) for Namibian museums, with the integration of RFID technology, using the Independence

Memorial museum as the case study. The PSS is used to track the amount of time visitors have spent focusing on each of museum artefacts. Based on the PSS, visitors were presented with a souvenir card containing two components: (1) a visitor's image and (2) the image of the artefact that the visitor has spent more time focusing on, with a text description of that artefact. Overall, the PSS has been successfully developed and satisfactorily achieved and fulfilled the specified objectives and requirements. The study also reviewed the state of the art in the fields of museums, persuasive computing, location based systems and enhancement of museums visits. Furthermore, the study presented scientific critics towards existing solutions that aims at solving the low turnout to museums and proposed a new solution to increase the museum turnouts. However, due to limited time, the study could not prove if the PSS is indeed able to convince visitors to revisit the museum or to attract new visitors to the museum. The persuasive component evaluation is part of the future works and it will need to be tested in a long-term process.

## References

- Adhiambo, D. (2018). System Design in Software Development. *The Andela way*.
- Alexander, J., Barton, J., & Goeser, C. (2013). Transforming the Art Museum Experience: Gallery One. *Museums and the Web*.
- Amran, Z. A., & Admodisastro, N. (2017). Designing an Interactive Learning to Enrich Children's Experience in Museum Visit. *Advances in Visual Informatics*, 601-611.
- Arinze, E. N. (1998). African museums: The challenge of change. *Museum International*, 31-37.
- Arulogun, O. T., Olatunbosun, A., Fakolujo, O. A., & Olamiyi, O. M. (2013). RFID-Based Students Attendance Management System. *International Journal of Scientific & Engineering Research*, 1-9.
- Bettigole, A., Candanedo, N., Gencorelli, M., & Newell, M. (2017). *Visitors, Museums, and Mobs*. An Interactive Qualifying Project Proposal Submitted to the faculty of Worcester I.
- Britain Thinks. (2013). Public perceptions of - and attitudes to - the purposes of museums in society. *London: Museums Association*, 50.
- Busch, C., & Sieck, J. (2015). Culture and Computer Science / Kultur und Informatik: Cross Media. *Culture and Computer Science – Cross Media*. Berlin.
- Cambridge University Press. (2019). *Cambridge University Press*. Retrieved April 1, 2019, from Cambridge Advanced Learner's Dictionary & Thesaurus: <https://dictionary.cambridge.org/dictionary/english/souvenir1>
- Carr, M. (1998). Prototyping and Software Development Approaches. *Semantic Scholar*.

- Chen, K.-Y., Harniss, M., Lim, J., Han, Y., Johnson, K., & Patel, S. (2013). uLocate: A Ubiquitous Location Tracking System for People Aging with Disabilities. *International Conference on Body Area Networks*, (pp. 7-10).
- Chung, L. (n.d). *Non-Functional Requirements*. Retrieved December 13, 2019, from University of Taxes at Dallas website: <https://personal.utdallas.edu/~chung/SYSM6309/NFR-18-4-on-1.pdf>
- City of Windhoek. (2016). *City of Windhoek*. Retrieved April 22, 2019, from Councillor Ogranogram 2016: <http://www.windhoekcc.org.na/pdf/Councillor%20Ogranogram%202016.pdf>
- Creswell, J. W. (2009). *Research Design: Qualitative, Quantitative, and Mixed methods approaches*. India: SAGE Publications.
- Curators, I. M. (2019, March 21). Personal Communication. (N. Nashandi, Interviewer)
- Curators, M. (2019, March 21). Personal Communication. (N. Nashandi, Interviewer)
- Degu, G., & Yigzaw, T. (2006). *Research Methodology Lecture Notes for Health Science Students*. Retrieved May 27, 2019, from [https://www.cartercenter.org/resources/pdfs/health/ephti/library/lecture\\_notes/health\\_science\\_students/ln\\_research\\_method\\_final.pdf](https://www.cartercenter.org/resources/pdfs/health/ephti/library/lecture_notes/health_science_students/ln_research_method_final.pdf)
- Del Bimbo, A. (2017). Making a Cultural Visit with a Smart Mate. *Proceedings of the 2017 ACM on International Conference on Multimedia Retrieval*, (pp. 2-2).
- Dynamic Digital Advertising. (n.d). *Glossary: Interactive Enviroment*. Retrieved October 20, 2019, from Dynamic Digital Advertising: <https://www.zerozerozero.com/glossary/interactive-enviroment.html>

- Floyd, C. (1984). *A Systematic Look at Prototyping*, in: Budde, R.,Kuhlenkamp, K., Mathiassen, L. and Zullighoven, H. (Eds.)*Approaches to Prototyping*. Berlin Heidelberg: Springer-Verlag.
- Fogg, B. J. (1998). Persuasive Computers:Perspectives and Research Directions. *CHI'98 Proceeding of the SIGCHI Conference on Human Factors in Computing Systems*, 225-232.
- Fogg, B. J. (1999, May 1). Persuasive Technologie. *Persuasive Technologie*301398. Retrieved from <https://cacm.acm.org/magazines/1999/5/7910-persuasive-technologie301398/fulltext>
- Fogg, B. J. (2009). Creating persuasive technologies: An eight-step design process. *4th International Conference on Persuasive Technology*. New York: ACM.
- Foley, M., & McPherson, G. (2000). Museums as Leisure. *International Journal of Heritage Studies*, 161-174.
- Forget, A., Chiasson, S., Van Oorschot, P. C., & Biddle, R. (2008). Improving text passwords through persuasion. *SOUPS: Symposium On Usable Privacy and Security*, (p. 1). Pittsburgn.
- GAO RFID Inc. (n.d). *2.45GHz Active RFID tags*. Retrieved December 12, 2019, from GAO RFID Inc: <https://gaorfid.com/devices/rfid-tags-by-frequency/active-2-45-ghz-rfid-tags/>
- GOA RFID Inc. (n.d). *2.45 GHz Gain Adjustable Active RFID Reader/Receiver*. Retrieved December 12, 2019, from GOA RFID Inc website: <https://gaorfid.com/product/reader-receiver-gain-adjustable-active-2-45-ghz-rfid/>

- Goel, R., & Gupta, N. (2004). *Survey on Acceptance Testing Technique*. Retrieved December 21, 2019, from Semantic Scholar: <https://www.semanticscholar.org/paper/Survey-on-Acceptance-Testing-Technique-Goel-Gupta/94bd57be619457f40e8fa67241514e1dc2b9c417#references>
- Gupta, A. (2010). Testing Functionality Requirements using B Model Specifications. *ACM Software Engineering Notes*.
- Gurr99. (n.d). *What is Security Testing? Types with Example*. Retrieved December 2019, 2019, from Gurr99: <https://www.guru99.com/what-is-security-testing.html>
- Hightower, J., & Borriello, G. (2001). Location Systems for Ubiquitous Computing. *IEEE Computer*, 57-66.
- Hood, M. (1983). Staying Away: Why people choose not to visit museums. *Museum news*.
- Hsi, S. (2004). I-guides in progress: two prototype applications for museum educators and visitors using wireless technologies to support science learning. *IEEE INTERNATIONAL WORKSHOP ON WIRELESS AND MOBILE TECHNOLOGIES IN EDUCATION* (p. 187). JungLi, Taiwan, Taiwan: IEEE.
- International Council of Museums. (2017). International Council of Museums (ICOM) - Statutes. As amended and adopted by the Extraordinary General Assembly on 9th June 2017 (Paris, France).
- Jitnupong, B., & Jirachiefpattana, W. (2018). Information System User Interface Design in Software Services Organization: A Small-Clan Case Study. *3rd International Conference on Electrical Systems, Technology and Information*. Bali Indonesia: MATEC Web of Conferences.

- Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. India: New Age International (P) Ltd.
- Kris, W. (n.d). *What is a Relational Database View?* Retrieved November 5, 2019, from essentialSQL: <https://www.essentialsql.com/what-is-a-relational-database-view/>
- Lanir, J., Kuflik, T., Sheidin, J., Yavin, N., Leiderman, K., & Segal, M. (2017). Visualizing museum visitors' behavior: Where do they go and what do they do there? *UBIQUITOUS COMPUTING*, 313–326.
- Li, X., Zhang , D., Lv, Q., Xiong, J., Li, S., Zhang, Y., et al. (2017). IndoTrack: Device-Free Indoor Human Tracking with Commodity Wi-Fi. *ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 72.
- Mia. (2016, November 27). How can we encourage those who rarely visits museums to do so more often? Retrieved from <https://medium.com/@miaeveliina/how-can-we-encourage-those-who-rarely-visit-museums-to-do-so-more-often-441c27cf4770>
- Mikoluk, K. (2013, September 18). *XAMPP Tutorial: How to Use XAMPP to Run Your Own Web Server*. Retrieved December 2019, 20, from Udemy Website: <https://blog.udemy.com/xampp-tutorial/>
- Mokhtar, M., & Kasim, A. (2011). Motivations for visiting and not visiting museums among young adults: A case study on UUM students. *Journal of Global Management*, 43-58.
- Mugo, F. W. (2002). *Sampling in Research*. 1.
- Oinas-Kukkonen, H., & Harjumaa, M. (2009). Persuasive systems design: Key issues, process model, and system features. *Communications of the Association for Information Systems*, 485-500.

- O'Leary, Z. (2004). *The essential Guide to Doing Research*. New Delhi: SAGE Publications.
- Petrelli, D., Marshall, M. T., O'Brien, S., McEntaggart, P., & Gwilt, I. (2017). Tangible data souvenirs as a bridge between a physical museum visit and online digital experience. *Personal and Ubiquitous Computing*, 281-295.
- Pomberger, G., & Weinreich, R. (1994). The role of Prototyping in Software Development. *TOOLS 1994: 13th International Conference on Technology of Object-Oriented Languages and Systems, Versailles*,. Versailles: Research Gate.
- Rajeev , D. (2019, June 25). *Interactive Media*. Retrieved October 20, 2019, from Investopedia: <https://www.investopedia.com/terms/i/interactive-media.asp>
- Reges , S. (2002). Can C# Replace Java in CS1 and CS2? *Proceedings of the 7th annual conference on Innovation and technology in computer science education* (pp. 4-8 ). Tucson: ITiCSE '02 .
- Rubin, J., & Chisnell, D. (2008). *How to plan,design, and Conduct Effective Tests*. Indianapolis: Wiley Publishing,Inc.
- Salas, P. P. (n.d). *Performance Testing*. Retrieved December 17, 2019, from The Austrail and New Zealand Testing Board: <https://www.anztb.org/userfiles/files/PerformanceTestingQLD0414.pdf>
- Sanjay, K. (2016, March 18). *How to do NFR Testing(Non Functional Requirements)*. Retrieved November 29, 2019, from Capgemini: <https://capgemini.github.io/testing/how-to-do-nft/>
- Sarwar, T., Habib, W., & Arif, F. (2013). Requirement Based Testing Software. *IEEE*.

- Satoh, I. (2008). Experience of context-aware services in public spaces. *Proceedings of the 5th international conference on Pervasive services* (pp. 81-90 ). Sorrento: ACM.
- Silvester, J., & Pujatura, G. (2016). *Making Museums Matter: A marketing Handbook for Namibian Museums*. Retrieved April 22, 2019, from journal-and-publications: <https://www.museums.com.na/images/pdf/Marketing-Handbook.pdf>
- Software Testing Fundamentals. (n.d). *Fuctional Testing*. Retrieved November 2019, 2019, from Software Testing Fundamentals: <http://softwaretestingfundamentals.com/functional-testing/>
- Software Testing Fundamentals. (n.d). *White Box Testing*. Retrieved November 07, 2019, from Software Testing Fundamentals: <http://softwaretestingfundamentals.com/white-box-testing/>
- Srivastava, B. (2017, January 30). *History Of C# Programming Language*. Retrieved July 22, 2019, from c-sharpcorner: <https://www.c-sharpcorner.com/blogs/history-of-c-sharp-programming-language>
- Thakur, D. (n.d). *Client Server Architecture*. Retrieved July 10, 2019, from ecomputernotes: <http://ecomputernotes.com/computernetworkingnotes/network-technologies/what-is-client-server-architecture>
- Thakur, D. (n.d). *Discuss the Objectives of the Design Phase*. Retrieved July 10, 2019, from ecomputernotes: <http://ecomputernotes.com/software-engineering/discuss-the-objectives-of-the-design-phase>
- Toscos, T., Faber, A., An, S., & Gandhi, M. P. (2006). Chick clique: persuasive technology to motivate teenage girls to exercise. *CHI* (pp. 1873–1878). Canada: ACM.

Wang, Y., Yang, C., Lei, S., Wang, R., & Meng, X. (2007). A RFID & handheld device-based museum guide system. *2nd International Conference on Pervasive Computing and Applications, ICPCA'07*, (pp. 308-313).

Webster's New World College Dictionary. (2014). *Webster's New World College Dictionary*. Retrieved April 1, 2019, from Your Dictionary: <https://www.yourdictionary.com/persuasive>

Zbucheá, A. (2013). How do young people visit museums? *Qualitative Research in Communication*.

## APPENDICES

### Appendix A: PSS prototype usability testing's post-testing questions

1. Do the system functions work accordingly?
  - a. Excellent
  - b. Good
  - c. Satisfactory

- d. below average
  - e. Poor
2. Do you feel this prototype is easy to use for the operation?
- a. Excellent
  - b. Good
  - c. Satisfactory
  - d. below average
  - e. Poor
3. Is the graphic user interface design attractive?
- a. Excellent
  - b. Good
  - c. Satisfactory
  - d. below average
  - e. Poor
4. Overall how do you find the prototype?
- a. Excellent
  - b. Good
  - c. Satisfactory
  - d. below average
  - e. Poor
5. Would like to include more features, improve existing one or add other functionalities to the prototype?
- a. No
  - b. Yes
- If yes, please comment

---

---

---

---

## **Appendix B: online questionnaire**

Dear Respondent,

I am a Master student at Namibia University of Science and Technology in the department of Computer Science: Software Development carrying out an academic research on the topic "A PERSUASIVE SOUVENIR SYSTEM (PSS) TO INCREASE NAMIBIAN MUSEUMS TURNOUT USING RFID TECHNOLOGY". I wish to request for your assistance to complete this questionnaire as your responses would enable me to

conclude on my research. I assure you that the information provided will be strictly for academic purpose and will be treated with utmost confidentiality. Thank you for your time.

1. Have you been to a museum?

Yes

No

2. If your answer to questions 1 is **no**, select the reason why you could not go and visit a museum?

Lack of interest

Lack of attractiveness

Museums are boring

Have more funny things to do like going to restaurants, church etc.

I don't know where are museums are located in Windhoek

Others

If you are answer is others, please specify:

.....  
.....  
.....  
.....

3. If your answer to questions 2 is **yes**, which of the museums in Windhoek have you visited?

Owela Museum

National Earth Sciences Museum

Independence Memorial Museum

Alte Feste Museum

TransNamib Railway Museum

4. How often do you visit museums?

Never

After my first visit, I have not gone back

Yearly

Monthly

Others

5. What was the most interesting thing you saw in the museum?

.....  
.....

6. Traditionally, museums exhibit their arts by displaying the arts and a short description about the art printed on paper attached on the art/drawing/handcraft. Nowadays museums have embraced the use of technology and have incorporated it, in the way they present their arts to guests to make them more attractive to visitors. Technology is being used in museums nowadays by providing new ways to encourage visitors to be parts of the exhibitions and provide interactive experience to visitors. The use of digital devices like smart phones, tablets, smart watches etc. to give museums visitors more extra information about the art, more personalized visiting journey and self-guiding tour are rated as technology. How could you rate the use of digital/ media technology (display, interactive platform, etc.) at the museum that you visited?

No technology

Poor

Moderate

Advanced

7. With technology being part of our everyday life do you think if we integrate technology in museums, it will make it more attractive/appealing or interesting?

Explain

.....  
.....  
.....  
.....

8. Would you mind having your photo taken at a Museum?

No

Yes

9. Would you mind to carry a visitor's card holder within the museum?

No

Yes

10. The study purpose is to create Persuasive souvenir system that will have tracking component to count the amount of time you spend in front of each artefacts and award you with a souvenir/ gift card consisting of photos of you and artefacts you mostly spent admiring at the museum. Would you mind being tracked in the museums for a system prototyping testing?

Yes

No

11. What will be your reaction if you are presented with a souvenir/ gift card consisting of photos of you and an artefact/art/drawing that you mostly spent admiring at the museum?

Happy

Surprised

Sad

No reaction/don't care

## Appendix C: source codes

```
//start listen
private void Listen()
{
    try
    {
        //server port is always 8900
        int nPort = Convert.ToInt32(this.textBox1.Text); ;

        if (listener != null)
            listener.Close();
        if (clientSocket != null)
            clientSocket.Close();

        IPEndPoint iep = new IPEndPoint(IPAddress.Any, nPort);
        listener = new Socket(AddressFamily.InterNetwork,
SocketType.Stream, ProtocolType.Tcp);
```

```

        listener.Bind(iep);
        listener.Listen(100); // how many connects allowed from clients
        statusBar1.Panels[0].Text = "Listening on port: " + nPort.ToString();

        listener.BeginAccept(new AsyncCallback(AcceptCallback),
listener);

        }
        catch (Exception ex)
        {
            MessageBox.Show(ex.ToString());
        }
    }

    //accept reader connection
    public void AcceptCallback(IAsyncResult ar)
    {
        Thread.Sleep(100);
        try
        {
            Socket server = (Socket)ar.AsyncState;
            Socket client = server.EndAccept(ar);

            StateObject state = new StateObject();
            state.workSocket = client;

            //if (clientSocket != null)
            //clientSocket.Close();
            clientSocket = client;

            EndPoint tempRemoteEP = client.RemoteEndPoint;
            IPEndPoint tempRemoteIP = (IPEndPoint)tempRemoteEP;
            string rempip = tempRemoteIP.Address.ToString();
            string remoport = tempRemoteIP.Port.ToString();
            GUIControl.IListBoxAddItem(this, listBoxReaders, "[" + rempip + "]" - Port:"
+ remoport);

            //start receiving data from reader
            client.BeginReceive(state.buffer, 0, state.workSocket.Available,
SocketFlags.None, new AsyncCallback(readCallback), state);

            listener.BeginAccept(new AsyncCallback(AcceptCallback), listener);
        }
        catch (Exception ex)
        {
            MessageBox.Show(ex.ToString());
        }

        // server.Close();
        // client.Close();
    }
}

```

**Figure C-1 source code used to connect the RFID tags to RFID readers**

```
//handle received data
```

```

    public void readCallback(IAsyncResult ar)
    {
        Thread.Sleep(100);
        if (ar == null) return;
        StateObject state = (StateObject)ar.AsyncState;
        if (state == null) return;
        Socket handler = state.workSocket;
        if (handler == null) return;
        if (handler.Connected == false ) return;
        int bytesRead = handler.EndReceive(ar);

        try
        {
            if (bytesRead > 0)
            {

                EndPoint tempRemoteEp = handler.RemoteEndPoint;
                IPEndPoint tempRemoteIP = (IPEndPoint)tempRemoteEp;
                string rempip = tempRemoteIP.Address.ToString();
                string remoport = tempRemoteIP.Port.ToString();

                byte[] recvBytes = state.buffer;
                string status = null;
                List<RFIDTag> tags = new List<RFIDTag>();

                //Judge data head
                if ((recvBytes[0] == 66)
                    && (recvBytes[1] == 73)
                    && (recvBytes[2] == 83)
                    && (recvBytes[3] == 65)
                    && (recvBytes[4] == 95)
                    && (recvBytes[5] == 82)
                    && (recvBytes[6] == 70)
                    && (recvBytes[7] == 73)
                    && (recvBytes[8] == 68)
                    && (recvBytes[9] == 0))
                {

                    //judge data package type
                    if ((recvBytes[14] == 1) || (recvBytes[14] == 21) && (recvBytes[15]
== 0))
                    {
                        int len = recvBytes[13] * 256 + recvBytes[12];

                        //starting from byte[48], every 13 byte is a reading record
                        for (int i = 0; i < (len - 48) / 13; i++)
                        {
                            byte[] tagBytes = new byte[9];
                            status = null;

                            //find Tag ID
                            for (int j = 0; j < 9; j++)
                            {
                                tagBytes[j] = recvBytes[i * 13 + j + 48];
                            }

                            tags.Add(ConvertTag(tagBytes));
                        }
                    }
                }
            }
        }
    }

```

```

        if (tags.Count > 0)
        {
            //dev.NoticeTags(tags.ToArray());
            List<ListViewItem> items = new List<ListViewItem>();
            foreach (RFIDTag tag in tags)
            {
                string artefactName= getArtefactName(rempip);
                string sql = "insert into activeTags(artefactName,
tagId, timeRecorded, status)";
                sql += " values('" + artefactName + "', '" + tag.ID +
"', NOW(), 'Connected')";

                Globals.ExecuteNonQueries(sql);
                //find status
                // status = recvBytes[i * 13 + 8 + 48].ToString("X2");
                GUIControl.IListBoxAddItem(this, listBoxTags, "[" +
rempip + "]" - " + tag.ID + " - " + tag.Type + "-" + tag.Mount + " - " + tag.Temperature +
" - " + tag.Battery + " - " + tag.Buckle + " - " + tag.Vibration + " - " + tag.Call + " -
" + tag.ButtonPress);
            }
        }
    }
}

```

**Figure C.2: source code used to extra the tag id for the connected tag and record the time.**