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**DEPARTMENT OF INFORMATICS AND TELECOMMUNICATION**


**BSc THESIS**

# Experiencing the Ancient Agora of Athens through Emotionally-led Interactive Stories with Tangibles


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**ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ**

**ΣΧΟΛΗ ΘΕΤΙΚΩΝ ΕΠΙΣΤΗΜΩΝ**
**ΤΜΗΜΑ ΠΛΗΡΟΦΟΡΙΚΗΣ ΚΑΙ ΤΗΛΕΠΙΚΟΙΝΩΝΙΩΝ**

**ΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ**

# Εμπειρίες Επίσκεψης της Αρχαίας Αγοράς Αθηνών μέσω Ψηφιακής Εφαρμογής Αφηγήσεων με Συναισθήματα και Απτά Αντικείμενα

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# ABSTRACT

Cultural heritage sites are popular tourist attractions, yet it is common for visitors to leave feeling disengaged by the large amount of information provided, and emotionally detached. Curators are making considerable efforts to cater to their visitors' needs while exploring ways to serve their institutions' educational mission. Nowadays, the development of digital technology projects aims to alleviate such problems, making the museum visit more engaging. However, even so, digital applications in many cases sustain earlier didactic approaches and fall short from significantly redefining the way that visitors experience cultural heritage.

This thesis examines how the association of embodied and tangible interaction with emotion-driven storytelling can affect the way people experience cultural heritage sites and museums. Digital storytelling experiences were designed and implemented for both the outdoor archeological site of the Ancient Agora of Athens and its indoor museum. The outdoor experience aimed at exploring the use of a single story spanning across a large open space and was evaluated on site by a small but multidisciplinary user group. The indoor experience makes use of a custom tangible object and of a location-aware application to guide interaction through short emotionally-led stories, and was evaluated by 12 users. Our findings provide insights on those elements of the experiences that make them effective or not in the rich context of a cultural setting.



**SUBJECT AREA**: Human Computer Interaction

**KEYWORDS**: Digital Cultural Heritage, Tangible interaction, Emotion-Driven Storytelling, Location-aware technologies, Mobile application, Evaluation

# ΠΕΡΙΛΗΨΗ

Οι χώροι πολιτιστικής κληρονομιάς είναι δημοφιλή τουριστικά αξιοθέατα, αλλά αποτελεί σύνηθες φαινόμενο για τους επισκέπτες να φεύγουν από τους χώρους αυτούς με ένα αίσθημα απεμπλοκής λόγω του μεγάλου όγκου των πληροφοριών που παρέχονται και μη συνδεδεμένοι συναισθηματικά με την κληρονομία. Οι επιμελητές των μουσείων καταβάλλουν σημαντικές προσπάθειες για να ικανοποιήσουν τις ανάγκες των επισκεπτών τους εξερευνώντας τους τρόπους εξυπηρέτησης της εκπαιδευτικής αποστολής των θεσμικών οργάνων τους. Τα τελευταία χρόνια η ανάπτυξη έργων ψηφιακής τεχνολογίας στοχεύει στην άμβλυνση τέτοιων προβλημάτων, καθιστώντας την επίσκεψη του μουσείου πιο ελκυστική. Παρόλα αυτά, οι ψηφιακές εφαρμογές σε πολλές περιπτώσεις υποστηρίζουν προηγούμενες διδακτικές προσεγγίσεις και υπολείπονται από τον επαναπροσδιορισμό του τρόπου με τον οποίο οι επισκέπτες γνωρίζουν την πολιτιστική κληρονομιά. Αυτή η πτυχιακή εξετάζει πώς η συσχέτιση της ενσωματωμένης και απτής αλληλεπίδρασης με την αφήγηση που προκαλείται από συναισθήματα μπορεί να επηρεάσει τον τρόπο με τον οποίο οι άνθρωποι βιώνουν τους χώρους πολιτιστικής κληρονομιάς και τα μουσεία. Οι ψηφιακές εμπειρίες με βάση την αφήγηση σχεδιάστηκαν και υλοποιήθηκαν τόσο για τον υπαίθριο αρχαιολογικό χώρο της Αρχαίας Αγοράς της Αθήνας όσο και για το εσωτερικό μουσείο. Η υπαίθρια εμπειρία στόχευε στη διερεύνηση της χρήσης μιας ενιαίας ιστορίας που εκτείνεται σε ένα μεγάλο ανοικτό χώρο και αξιολογήθηκε επί τόπου από μια μικρή αλλά διεπιστημονική ομάδα χρηστών. Η εσωτερική εμπειρία χρησιμοποιεί ένα απτό αντικείμενο και μια εφαρμογή που λαμβάνει γνώση της θέσης για να καθοδηγήσει την αλληλεπίδραση μέσω σύντομων ιστοριών βασισμένων στο συναίσθημα και αξιολογήθηκε από 12 χρήστες. Τα αποτελέσματα της έρευνας μας δίνουν πληροφορίες για τα στοιχεία των εμπειριών που τις καθιστούν αποτελεσματικές ή όχι στο πλούσιο πλαίσιο ενός πολιτιστικού περιβάλλοντος.



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**ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ**: Ψηφιακή πολιτισμική κληρονομιά, Απτή διάδραση, Αφήγηση με βάση το συναίσθημα, Αφήγηση με διάδραση, Αξιολόγηση εμπειρίας χρήστη

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# PREFACE

This project was developed in the Department of Informatics and Telecommunications of the National Kapodistrian University of Athens as a bachelor thesis. Its duration from its start until its completion was a year.

# 1. INTRODUCTION

## 1.1 Subject of project & Motives

Athens is a city rich in cultural heritage sites. Particularly, Ancient Agora, where we are going to implement the project, is a popular tourist attraction. However, based on our observations and previous work done, a cultural activity such as visiting museums is not seen as one of the main ways that local people spend their leisure time. Additionally, the artifacts of heritage sites are mainly intangible while they carry a huge informative role. Hence, even though these places receive plenty of visitors each year, the gap between heritage and visitors constantly grows. Visits are restricted to sightseeing since no interaction is possible and, besides audio guides and maps, no other visit supportive material is available.

In order to stay competitive with other leisure activities, curators are making efforts to enhance heritage experiences. One of those ways has been introducing digital technologies such as mobile applications to the heritage setting. As a consequence, there has been a growing interest in understanding how digital technologies could be used to improve the cultural heritage experience of visitors and mediate their interpretations of the heritage. Digital heritage research has mainly concentrated on finding new ways to avoid heritage's informative role and trying to turn visits into a more entertaining experience. Storytelling often appears as a promising solution to create more immersive experiences. Nonetheless, the way that it is currently handled does not change the way with which visitors approach heritage. The common choices to enhance a visitor's heritage experience are focused on well-designed audio guides and VR/AR games. In this case, we want to avoid the gamification of experience and insist on a simple, yet different experience that understands users' needs and location characteristics and forms a powerful experience inside or outside the Ancient Market.

Storytelling in the context of cultural heritage is a basic point of our work. Recently a new approach to digital heritage storytelling experiences is being proposed. Emotion-driven storytelling is aiming to increase visitor's empathy for cultural heritage and historical figures and create more meaningful experiences [16]. As the research in this area is still in its infancy, little work has been done that focuses on a more emotive view of the heritage experience. The cultural heritage curators have begun to realize that visitors should be seen as active participants who can forge their own meanings and interpretations of the heritage, rather than being seen as passive receivers of information.

## 1.2 Project Goal

The goal of this thesis is twofold: firstly, to explore how emotion-driven storytelling can improve the way visitors experience cultural heritage. Secondly, to explore how an embodied experience based on a combination of tangible interaction and location-aware mobile application can increase the engagement of visitors to heritage sites where heritage is not tangible. We want to focus more on the cohesion between the environment and the visitor and enhance their visit. In this sense, the mobile application does not form the center of this work. Instead, we shift and place the users and their experience in the center of design and development.

## 1.3 Project Structure

The project is structured as follows:

In Chapter 2, the literature review is presented as well as related work. A framework for understanding digital heritage is introduced. Research projects that inspired this work are also discussed.

In the next chapter, we refer to heritage site characteristic and audience and we design an outdoor and indoor experience. Chapter 3 outlines this project's approaches and methods for the designing of a digital storytelling experience. The findings of a primary formative in situ evaluation of a first experience design are also presented.

Chapter 4 presents the technologies used for the implementation of the main experience and its structure.

Finally, Chapter 5 presents the methodology, the procedure and the findings of the experience evaluation and chapter 6 concludes the project by summarizing the research outcomes and how they answer the initial research goals. The reflections that follow outline the areas that this project did not manage to cover and that could be addressed in the future.

At the end of this thesis, there are four annexes. In Annex I, indicative code parts are displayed, in Annex II the final form of the indoor experience is presented accompanied with photos of the tangible and the application, in Annex III the invitation of participation in the evaluation is cited and in Annex IV an in situ experience by members of Agora's staff is presented.

# 2. BACKGROUND & RELATED WORK

## 2.1 Emotional Design

This project aims to develop a user-centered digital cultural heritage experience. The focus is given on user needs and emotions developed through this experience and related with the museum artifacts, the application etc. As a result, we need to follow a design procedure which emphasizes the importance of the user's emotions. Emotional design better fits into the project's mentality and it is described in the following chapters.

### 2.1.1 What is emotional design?

Emotional design [24] strives to create products that elicit appropriate emotions, in order to create an engaging, positive or negative, experience for the user. To do so, designers consider the connections that can form between users and the objects they use, and the emotions that can arise from them. A product can elicit emotions that have a strongly influence on users' perceptions of it.

Emotions play a central role in the human ability to understand and learn about the world. Positive experiences kindle our curiosity, and negative ones protect us from repeating mistakes. Humans form emotional connections with objects on three levels: the **visceral**, **behavioral**, and **reflective** levels (Figure 1). A designer should address the human cognitive ability at each level. A positive experience may include positive emotions (e.g., pleasure, trust) or negative ones (e.g., fear, anxiety), depending on the context (for example, a horror-themed computer game or a drama-based audio guide).


**Figure 1: Don Norman's Level of emotional design. Image downloaded from: https://www.interaction-design.org/literature/article/the-reflective-level-of-emotional-design**

### 2.1.2 Levels of emotional design

**Visceral emotional design** is the most immediate level of processing, in which we react to visual and other sensory aspects of a product that we can perceive before significant interaction occurs. It mainly deals with aesthetics and the perceived quality from look and feel and the engagement of senses. Visceral processing helps us make rapid decisions about what is good, bad, safe, or dangerous.

**Behavioral emotional design** is the middle level of processing that lets us manage simple, everyday behaviors, which according to Norman, constitute the majority of human activity (Figure 2). It mainly refers to the usability of the product, our assessment (of how well it performs the desired functions, and how easily we can learn how to use it. By this stage, we will have formed a more justified opinion of the item. Norman states that, historically, interaction design and usability practices have primarily addressed this level

of cognitive processing. Behavioral processing can enhance or inhibit both lower-level visceral reactions and higher-level reflective responses, and conversely, both visceral and reflective processing can enhance or inhibit behavioral processing.

Finally, **reflective emotional design** is the least immediate level of processing, which involves conscious consideration and reflection on past experiences. It is concerned with our ability to project the product's impact on our lives after we have used it—e.g., how it makes us feel when not holding it, or what values we find ourselves attaching to the product in retrospect. Reflective processing can enhance or inhibit behavioral processing, but has no direct access to visceral reactions. This level of cognitive processing is accessible only via memory, not through direct interaction or perception. The most interesting aspect of reflective processing as it relates to design is that, through reflection, we are able to integrate our experiences with designed artifacts into our broader life experiences and, over time, associate meaning and value with the artifacts themselves.

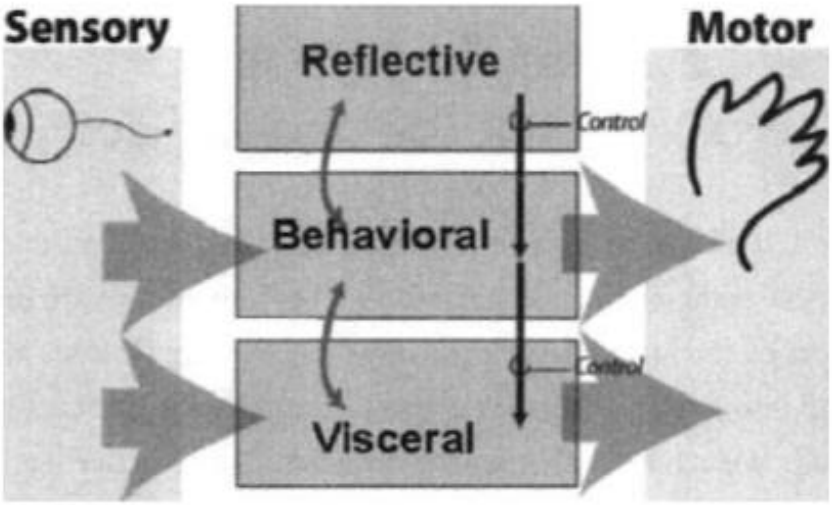



**Figure 2: Three levels of processing: Visceral, Behavioral and Reflective. Image from D. Norman, "Emotional design. Why we love (or hate) everydaythings", Basic Books, 2004, pp. 63-98.**

### 2.1.3 The reflective level of emotional design

As reflective level is the most long-term stage of emotion design we chose to investigate further the actions which influence this part.

Some reflective operations can influence the decisions we make and the emotional attachments we form with different items in our environment. Firstly, we distinguish the analyzing superficial qualities**,** which might be according to our present likes/dislikes, how we feel at the time, where the product will go, how you intend to use it, and who will see it.

Secondly, other important reflective operation is the reflecting on past experiences. How did we last feel when using a particular product? If product's possesses qualities are similar to an object we have used previously, it might evoke some of the emotions and thoughts aroused at the time. Reflective processing takes place when we access things in long-term memory to make value judgments. By reflecting on past experiences and relating these to the products we are using, everyday things are incorporated into our overall experience of the world—and they become as much a part of our memories as what we are doing, who we are with, and where we are. Many products are now even part of the memory-forming experience; cameras, iPhones, and computers – all of these

things help us mark occasions and collect mementoes, and they provide us with a permanent record of our activities.

Finally, the attaching meaning for personal development also affects our decisions and emotions. When we look at a product, we sometimes project our thoughts, attitudes, hopes, and intentions onto it. For example, millions of people, at the start of every year, seek out and spend millions of dollars on exercise equipment. All of these purchases are based on the desire for a new, better 'you', and the products people buy represent this drive. Products are part of people's lives, and they are now used as symbols of who our personality. The challenge of emotional design is to show the product in a way that plays on the desires of the current target market. Giving an attaching meaning to products is a complex task requiring knowledge of current target market, users' culture, and some psychology.

### 2.1.4 Plutchik's wheel of emotions

Design which tap into user's emotions is more than just respond to the stated needs. One way of understanding emotions is Plutchik's Wheel of Emotions. Plutchik's wheel gives to user a way of expression.

Robert Plutchik, was a thought leader in the study of emotions and devised the psycho-evolutionary theory of emotion and this helps categorizing emotions into primary emotions and the responses to them. He argued that the primary emotions are an evolutionary development and that the response to each such emotion is the one that is likely to deliver the highest level of survival possibility.

He posited 10 points with regard to emotion:

- Emotions are found at all evolutionary levels of species. They are equally applicable to all animals as they are to human beings.
- Emotions evolved differently in different species and may be expressed differently between those species.
- The purpose of emotions is an evolutionary survival response enabling the organism to survive when confronted by environmental challenges.
- While emotions can be displayed and evoked through different mechanisms in different organisms there are common elements to emotions that can be identified across all emotional animals.
- There are 8 basic, primary emotions.
- Other emotions are simply a combination of these 8 basic emotions or are derived from one (or more) of these basic emotions.
- Primary emotions are "idealized" and their properties must be inferred from evidence but cannot be accurately stated in full.
- Each primary emotion is paired with another and is a polar opposite of that pair.
- Emotions can and do vary in degrees of similarity to each other.
- Emotions exist in varying degrees of intensity.

The 8 basic emotions that Plutchik devised were: Anger, Disgust, Fear, Sadness, Anticipation, Joy, Surprise and Trust. It is really useful that Plutchik's wheel supports other more complicated emotions by combining basic emotions (Figure 3).


**Figure 3: Plutchik's wheel of Emotions. Image from: www.positivepsychology.com**

### 2.1.5 Criticism of Plutchik's wheel

Our main criticism of this model is its failure to take into account the pairing of Pride and Shame. These are emotions which designers often play to. For example, gamification efforts may attempt to tap into a user's pride through leaderboards or badges. Conversely charitable and campaigning organizations may try to tap into shame to encourage action. [https://www.interaction-design.org/literature/article/putting-some-emotion-into-your-design-plutchik-s-wheel-of-emotions]

It is also often felt that the model is too simplistic and that there are greater emotional nuances not captured within it. However, it is generally agreed that the Wheel of Emotion is a good starting point when considering what emotions a design may elicit.

### 2.1.6 Summary

Studying the emotional design approach gave us important guidelines to inform the design of our storytelling experience. It enabled us to form an integrated perception towards user's emotions and needs.

One axis of emotion theory which was discussed in this section is color theory. Colors and psychology theory can be adjusted to our work. Plutchik's wheel of emotions is one example of color theory. Nevertheless different types of emotions categorization could be found, as Goethe's color wheel of emotions. We choose to adopt Plutchik's wheel because of its simplicity and convenient coverage of emotions.

## 2.2 Digital Cultural Heritage

During the last decade, there is a growing research interest towards digital heritage. Our project is placed in the museum and the outdoor site of the Ancient Agora (market) of Athens, therefore digital heritage is part of the project's general context and as part of it, it should be examined further.

### 2.2.1 When digital meets heritage

Heritage generally refers to something inherited from the past. The word has several different interpretations, including natural heritage, food heritage, tradition, but we focus on cultural heritage, in other words the legacy of physical artifacts and intangible values which have to be transmitted to future generations. However, heritage is not only the traces of past society and past times, for instance the ancient monuments or centuries-old paintings, but includes also the evidence of the present ones, which has to be passed down to our descendants as well. Cultural heritage is unique and irreplaceable. It carries an enormous amount of information that the current generation holds the responsibility of preserving it for future generations' benefit.

Over the last decade, digital mobile technologies have played a leading role in transforming the visitor experience at sites of heritage all over the world. Different research programs, interactive exhibits made their appearance exploring the role of digital in heritage.

During the last century, digital technologies did not only appear in the cultural heritage area but generally, they have dominated everyday life and affected the relationship between people and knowledge. As a matter of fact, the majority of people now expect hyper-contextual information and they expect it quickly. Context can be delivered in a variety of ways, while content and knowledge frequently have become non-linear. Hence, since cultural heritage sites are a hub of knowledge for many of us, technology cannot be kept away from these places. In any case, the question that we should be asking is "how can we use mobile and digitally enhanced forms of interpretation to change the questions we ask and the ways in which we engage with historic sites?"[1].

Digital is able to play a leading role in cultural heritage about key issues as providing access, enhancing interaction and sharing knowledge. In exhibition design, digital technology is now seen as a "must have". However, it is often used as an "add on" (e.g. more information or a different experience) rather than an integrated element of a complex and multi-channel communication between the cultural institution and the public [2].

Designing tools and apps for digital heritage seems a demanding process. The presence of technology do not guarantee a better outcome. Thus, in the list below we collected a number of suggested practices and general guidelines by specialists[3], for a successful designing of harmonic digital heritage experiences.

- Have a Vision. Above all else, identify a strong, clear vision for a project in the very earliest stages.
- Use a little technology well, not a lot of technology poorly.
- Take more chances with design and experience. Most projects are an opportunity to question or validate assumptions, try new variations, or learn something new
- Break out of the traditional models of exhibit development. Traditional exhibit design approaches content top-down and often turns interactive installations and other technologies, such as mobile experiences, into an afterthought. Instead of focusing on

the physical space, then content and associated detail, and finally supporting media assets, have the smallest elements push back up the food chain and inform the overall design.

- Good storytelling requires good editing because not everything that can make it into an interactive experience.

- Technology is a last resort. With powerful technology comes great responsibility. Technology used as a container for the content that could not make it into an exhibit is a poor use of technology.

- Social media needs to be social. Social media opportunities should focus on sharing and giving visitors a voice and should not automatically be included in every new project.

- Create multidisciplinary teams. The juxtaposition of different ideas often leads to great moments of inspiration.

As cultural heritage is very important part of Greece and as the goal of our project is to form a digital experience inside the Ancient agora, the ways in which digital technologies have been considered for use in the heritage environment: mobile and tangible interaction, should be explored further. This work aims to understand the challenges of designing an experience for digital heritage and to draw on some guidelines.

## 2.3 Cultural Heritage Locations

Before continuing with further information about digital cultural heritage, it is very important to distinguish heritage locations into outdoor and indoor sites, such as museums. Different forms of cultural heritage have different characteristics and requirements, as much as they require different personalization formats concerning the user. Hence, there is a difference between museums (indoor) and historical locations (outdoor) that we should investigate.

### 2.3.1 Outdoor Locations

The outdoor locations pose a set of specific challenges and offer a number of unique opportunities. In historical locations, social and political functions of each location are reflected [4].

To start with, the visit is a full-body experience; the spaces to cover are larger than when moving from exhibit to exhibit and from room to room, while a sense of anticipation may be created. When the destination is reached, this feeling of anticipation can affect visitor's immersion. While engagement in a museum tends to be via prolonged observation, in an outdoor setting multiple senses are stimulated: there is the physical, full-body experience of being there, the sight and the sound of the surroundings, possibly the smell too. The multisensory setting places the visitor in direct connection with the heritage and enables engagement at an emotional, affective level rather than at a pure informative level [5] Regarding the outdoors one should avoid the delivery of information, but instead that forms of content delivery that, by design, aim at inducing an emotional response can be more effective outdoors than indoors because of this multisensory context.

From a technical point of view the outdoors can be really challenging: power supply may be limited or non-existent, Wi-Fi is highly unlikely to be available and even mobile phone signal may be limited if the heritage is located in a remote place. Mobility is an obvious solution for the personalization of the access to cultural heritage. Wireless applications are relevant for outdoor locations for two reasons: the first is that it is not possible to arrange variable spatial layouts for enhancing presentations and the second is to

guarantee a continuity in the presentation through a unique device that is bound to an individual visitor.

As a result the preferred device for such environments has so far been mobile technology, most recently apps for smartphones. While the use of a mobile device can solve technical issues, we have to bring out that empirical work on the use of mobile devices in museums has clearly shown that attention is diverted from the heritage onto the device, even to the point in some cases of ignoring the original [6]; or choosing what to look at on the basis of what is on the screen rather than what is of interest; or to spend time with the device in order to understand how it works.

In most cases, location-based Mixed Reality Environments (MREs) overlay digital information on the physical world. Examples of studies in this area range from artistic experiences to understanding and learning about the physical environment. However, the majority of previous research has been focused in urban environments, either on built-up city streets or in small pockets of nature in the city. Almost no research has considered a rural environment in which many un-stewarded archaeological sites are found. Previous work in urban environments has shown that the physical space exploited has a strong influence on user experience. While rural sites may provide high-quality GPS signals, they are unlikely to have good (if any) network access. [7][8]

### 2.3.2 Indoor Locations

In indoor heritage sites, such as museums, collections derive from heterogeneous sources. Therefore there is a strong need of experts to give a continuity to each exhibition. No matter what is the subject, the theme of the exhibition, the goal remains the same; provide an interpretative mediation between the items of a collection and the visitor. Since it is unlikely that the same mediation works for the totality of the visitors, personalization in museums attempts to fill this gap by setting up ‘different exhibitions’ to match the interests and expertise of different categories of visitors [4].

Another issue of indoor heritage locations is the object-centered mentality. In most sites, emphasis on informational content is given and information delivery is mainly done using text and audio; usually, the visitor is not accounted for and does not form the center of the visit.

### 2.3.3 The Antonine Wall

An interesting example of outdoor heritage location is the Antonine Wall project, not only because of its location, but also because of the current state of its remants. The Antonine Wall (www.antoninewall.org), running from the west to east coast of the central belt of Scotland, represents the most northern settlement of the Roman Empire in Britain. This places it on the same level of international historical and cultural importance as sites such as the Sydney Opera House and the Great Wall of China. Yet, unlike those sites, few obvious visual physical remains exist, and those that do are spread over several hundred kilometers of rural countryside. Despite the fact that the parts of the wall are accessible to the public, they are unstaffed and have no other facilities such as visitor centers. Any archaeological finds that were uncovered have been moved off-site to museums many miles away. We term these as un-stewarded archaeological sites. As there is no staff, only a few signs illustrate the importance of the site. Many findings have been discovered at the fort, but all have been removed to museums in the surrounding area.

Digital technologies as an interactive application that brings people of the site alive were developed to improve the regular site’s visit. The findings collected during project’s evaluation, brought out the following design implications for digital cultural heritage experiences in outdoor rural locations [9].

- **Encourage Exploration:** The physical space exerted a strong influence over participants. The “patchy” nature of remains at un-stewarded sites demands that users be supported to explore, and thus understand, the entire site, even those parts where no remains exist. The use of environmental sound as a means to encourage users to move and explore was only partly successful, helping users locate finds but not pulling them to areas with no visual remains.

- **Balance content:** Users immediately embraced the findings and the physicality of their discovery. Characters, although real actors were used, received a more neutral acceptance or were dismissed after a few seconds. Users will listen to the sound for a maximum of around 30 seconds before cutting it off.

- **Support reflection and understanding:** Reflecting upon an experience allows greater learning and understanding to take place. The issue with un-stewarded archaeological sites is that these activities were unique to this study: in real life, users making independent visits would not be debriefed after a day out, and the lack of staff or guides makes the kind of reflection previously employed in MRE studies impractical. New ways to allow this need to be developed. One option might be to again exploit the natural feeling of discovery exhibited by participants, by providing the location of the museum where the real find is held. Being able to visit and see the find that was virtually excavated may provide the distance and space necessary to allow for reflection.

Antonine wall project offers a complete understanding of the proper design for rural heritage sites and the guidelines that we should know before design a similar experience. Un-stewarded archaeological sites pose a series of technical obstacles which seem very challenging for further research.

### 2.4 Mobile Technologies in Cultural Heritage

Digital mobile applications exploiting cultural heritage content have come of age as evidence of multiple research projects, system providers, software/media production companies, and successful deployments in museums and cultural sites worldwide [10]. From the typical multimedia guided tours to the more elaborate mobile Augmented Reality (AR) activities, mobile technologies are credited for ensuring access to vast amounts of information, catering to differing visitor styles, interests and needs. They are perceived by the cultural institutions themselves as a means to bring multiple and new voices into the visitor experience, extend audience reach by attracting new/young audiences, provide varying layers of interpretation (e.g., introductory or highlights tour), support access for visitors with special needs and offer an overall engaging and interactive experience.

From the early experiments of the ‘90s on delivering content adapted to the specific visiting context, the use of mobile technology in museums sites has become, in the late ‘00s, more common and it is now a must [2].

The use of mobile technologies varies between institutions. Today’s mobile apps deliver multiple layers of multimedia content to visitors who can dig into specific artworks, offer games to amuse both children and adults, use augmented reality to provide content in context, and offer a range of additional information services such as visiting planners and interactive maps. [2] Nowadays in the center of interest for most digital cultural experiences, storytelling experiences are found.

A typical and the most common use of mobile technologies to cultural sites (indoor and outdoor) is the downloadable tour apps or audio-guides provided by museum curators. Typically, apps of this kind use locative GPS software and a simple mapping system to guide users around a town’s historic sites, alerting them on arrival at each with contextual

photographs or other contemporary illustrations, graphic reconstructions, and short snippets of information in text and/or audio format. The marketplace is an extremely competitive one. Academic historical input is rare in the development of apps like these; they tend to make use of previously published historical knowledge and materials rather than commission new research [1].

A second approach of digital mobile applications that exploit cultural heritage content is enhanced and affective simulations, such as 360 degree film or augmented and virtual reality (AR and VR) which have enabled enhanced forms of visual and audio reconstruction, particularly at archaeological sites, and in any historic landscape in which either material remains have not survived, or the desire for an experiential relationship with an historic event prompts virtual reconstruction.

Focused on museums for the next paragraphs, we should notice that the majority of museums nowadays offer mobile-based guided tours, whether these are museum-provided audio/multimedia guides that visitors can rent or borrow when in the museum, or applications that visitors can load onto their own smartphones and tablets (a.k.a. the “Bring Your Own Device” or BYOD model) and carry with them throughout the visit. The BYOD solution is gaining ground as it offers the advantage that most visitors already use their own devices, while it makes the mobile available to any museum [10]. However, in the Atlantic Wall [11] project evaluation, it was found that the highest percentage of participants that prefer not to use mobile apps explained that this is because the use of the phone gets in the way of the enjoyment of attending the exhibition or visiting it with others. There are museums for which BYOD is ideal, e.g. museums with a very high number of visitors for which crowd management is more urgent that visitors’ engagement. For the vast majority of museums, however, it is worth investigating other options than BYOD in light of the fact that its effect may by much more limited than it is currently expected.

Studies concerning the use of mobiles in museums have revealed several considerations and issues to overcome, including visitors’ distraction of attention away from physical objects; navigation and orientation shortcomings; restricted user control over the experience; and one-size-fits-all implementations that limit personalization. Most importantly, mobile applications, whether guided tours of exhibitions or free-choice presentations of exhibits, remain predominantly information providers [10]. This often didactic interpretive approach to presenting cultural content may compromise visitor engagement over time, resulting ultimately in an ineffective experience.

Mixed reality is a solution often used in digital heritage installations and whose systems can support rich social interactions among local and remote participants. Audio–based media spaces have been used before in workplace environments, and have been successfully used to establish communication and shared awareness among participants [12].

It is very important to notice that the evaluation of the impact of digital technology in museums is still considered a difficult challenge. There are well-established ways to measure if an exhibition reaches its aims, but there are currently no metrics or processes to evaluate the impact of technology in museums, if it reaches its aim and how it fits with the overall museum mission.

### 2.4.1 Challenges of a mobile application

Studies reveal that mobile museum visiting comes with a number of complex challenges that need to be addressed during design and/or deployment. The issues are defined as: Information (content) delivery, balance of the visitor attention between the environment

and the device, navigation, usability, social aspects, and personalization [8]. As a part of this project consists of the developing of a mobile application, it seems really important to analyze these challenges in order to be prepared to overcome the difficulties.

**Content delivery**

The issue of how the cultural content is to be delivered via a mediating mobile device within a meaningful physical space containing exhibits and other mediators is an outstanding one among researchers and practitioners in the field. Several studies reported that the presence of a mobile guide increased learning and attention, and that it was a source of motivation and inspiration to try new ways of interaction with the exhibition. Moreover, using of media may attract new audiences.

Concerning the style and structure of the information provided, studies have shown that visitors' physical and cognitive investment declines as the visit moves forward. Studies related to both outdoor and indoor heritage sites have reported that visitors prefer short, layered segments of audio, as it puts control into the hands of the user to decide whether or not to access additional interpretation. Danks et al. [13] note that 1.5 min is a maximum for a standing audience at a screen and that the length should be indicated to avoid visitors' discomfort and attention drifting away. On the other hand, additional music, images, video and sound effects should only be used when they enhance the interpretation, as visitors consider these distract them from looking at the real object.

**Screen vs Physical space**

Studies involving PDAs in art museums found that devices monopolize visitors' attention, instead of fomenting an egalitarian communication between objects, visitors and the device. Guidebooks and tours have the potential to help or hinder visitors as they strive for optimal attentional balance.

The surrounding environmental conditions are another relevant issue. The users found it difficult to locate the indicated location in crowded areas, but also that because they were too absorbed by the device, they were often unaware of other visitors and were jostled by them. In most of projects, headphones are used to tune out ambient noises.

**Location-Awareness navigation**

Location awareness in cultural settings remains an open issue for museum mobile applications, particularly in the case of indoor settings, in which automatic solutions are not mature enough to support accuracy of less than a 2–3 m range. As some visitors find it difficult to interpret floor plans, a solution has been to post markers (e.g., numbers, signs or even QR codes) near the exhibits or points of interest. However, such interventions can further complicate the visitor's immersive experience. In general terms, orientation issues have been poorly addressed.

Visitors often interact with sets of artifacts within a general area, and their decisions on what to look at are based not only on their personal interest and position, but also on their social interaction with their companions.

**Interface, Usability and Interaction**

It appears that more time for less familiar with technology users to understand the mediator, it doesn't have negative impact on the usability of interface. The main usability problems identified are related to the size of the screen: Small screens make difficult the manipulation of the displayed elements while bigger devices are cumbersome.

### Social Dimension of the visit

Visiting a museum in a group is, by definition, a collaborative activity. As McManus and vom Lehn [12] discussed in their studies, members of a group collaborate in the exploration of both galleries and displays by conversing with each other, animating the displays for each other and so forth.

Isolation between different members of a group of visitors when using electronic guides has long been cited as a disruption to the social aspects of a museum visit. Even though splitters require co-visitors to keep the same pace and listen to the same commentaries, discussion between visitors was rarely observed to occur.

### Personalization

Different visitors have different motivations for visiting and personalization has been proposed as the solution to the issue of accommodating different needs. By means of personalization, digital technology can match a visitor's profile to specific content thus providing different experiences to different people [10].Thematic visits and visits organized according to the user's available time are basic features of a personalized delivery of content. Finally, giving visitors control and choice concerning the amount of information are critical aspects of a digital experience.

## 2.4.2 The CHESS Project

CHESS, which stands for Cultural Heritage Experiences through Socio-personal interactions and Storytelling, is a project, co-funded by the European Commission that aims to integrate interdisciplinary research in personalization and adaptivity, digital storytelling, interaction methodologies, and narrative-oriented mobile and mixed reality technologies, with a sound theoretical basis in museological, cognitive, and learning sciences.

The principal objective of CHESS is to research, implement and evaluate both the experiencing of personalized interactive stories for visitors of cultural sites and their authoring by the cultural content experts.

Interactive experiences have been designed for and evaluated at two museums, each with a different scope and end-user requirements: The Acropolis Museum (AM) in Athens (Greece) which displays the archaeological findings of the Acropolis, and Cité de l'Espace in Toulouse (France), a science museum focusing on space and its conquest.

Focus on the interactive experience of Acropolis museum. Different sets of storytelling experiences were designed specifically for different visitor profiles or "personas", i.e., imaginary yet empirically grounded descriptions of typical visitors of the Acropolis Museum. Personas and the stories designed for them were conceived and evolved in a true human-centered design fashion. The experiences that were designed follow the same general structure, starting with an introduction to the story, which is delivered through narration as the user enters the museum gallery. Then a series of object-based or theme-based episodes are delivered, using narration and on-screen instructions to direct the user towards exhibits and, once the user confirms they are there, information is delivered relating to both the exhibit and the wider narrative. After all the exhibits have been visited, the experience concludes with a final piece of narrative, the ending of the story.

Each experience was delivered via a browser-based interactive application run on a tablet. The content was presented via audio narration and experienced with a set of headphones. In addition to the narration, images and animations were shown at times on the tablet's screen.

Moreover, the following main wayfinding approaches were considered: 1) Photo-based navigation support and 2) explicit confirmation through visitor input. The spatial proximity of the exhibits in the Archaic Gallery affects negatively the accuracy of location tracking technologies, making them inappropriate for this physical space. Consequently, the latter approach was implemented, depicting a photo of the corresponding destination on the screen and requesting from the visitor to verify successful arrival at the target destination by selecting “I’m there”.

**The findings**

As soon as our project includes a mobile application which will support visitor navigation through heritage site, it is useful to look into CHESS findings concerning mobile interaction challenges.

- Story flow and plot: Users tend to like the humor and the informal tone of narratives and links that may exist to everyday contemporary life. Fiction can empower visitor interest on facts, but she should know when the content is related or not to exhibits. Stories should remain short and avoid be totally informational while user stands on the same spot because she can get bored or tired easily. It is important that during the narration, user will always feel that she has the control of the story.

- Digital vs Physical: Of course visitors like the visuals which augment the experience. They believe that visuals give details that were not visible otherwise or relate informational content and artifacts. However, when a screen is presented, even when there is no need to look at it, users tend to pay a lot of attention on the digital. CHESS findings concerning the digital world vs the physical. A good practice of how to handle technology in a physical environment is to avoid having important content presented to the visitor while she has to navigate inside the site and presenting on screen images that the visitor can view in the physical space. It is not possible to focus equally on wayfinding and on understanding the offered content. Information on an object has to be presented only when visitor reaches object location.

- Wayfinding: Regarding the movement within the gallery, visitors reported that they like moving around in the gallery and they do not mind moving back and forth in a nonlinear fashion. While designing a digital cultural heritage experience, we should take into account: the visiting style (e.g., ant vs. grasshopper/butterfly), user’s preferred level of interactivity (guided vs. explorative) and the fact that visitors participate in an experience on-site, standing up and moving in physical space. There is not so much time before they get tired, physically or mentally, so the goal is to keep the stories short. During CHESS project in Acropolis museum it was observed that there is no need to be too explicit. By living the experience through a game process visitors are encouraged to move back and forth, to revisit/pass by exhibits they can now see from a different point of view. Detecting a user’s orientation (e.g., with a compass or even AR) makes things easier. However, in a museum this may be technically difficult to be done. The options of QR codes or NFC tags could be considered as ways for the user to check in at a specific location indoors during the experience.

- Interaction: Visitors like to be guided by the storytelling experience. They like to feel that they have the control of the story and interact with it. However, designers of digital heritage experiences should not promise interactivity and control to visitors if there is going to be none. Each type of visitor, those who prefer guided experiences and those who prefer more explorative and interactive ones, should have the choice of how much interactivity she wants.

- Temporal Interaction (Pre- and Post-Visit Activities) Perspective**:** It was observed that by providing options for post-visits & “souvenirs” and allowing content to be carried away from exhibits (e.g., ”Add to cart”, “Save for later”), a digital heritage experience can be improved and become more engaging. Additional information on the exhibits has to be available for museum enthusiasts.

- Social aspects**:** Heritage experiences are in general terms individual experience. Designing for groups is not an easy process, as most of visitors tend to isolate after a while in an exhibition, even without the presence of digital. Activities that promote social interaction and collaboration (e.g., every member of the group should have a role to play in order to reach a goal) shall be included. Collaboration between visitors is a great challenge for cultural institutions. Games or challenges increase social communication. If more devices are available, provide each group member the opportunity to experience a different story. For example, they may follow a different central character that has a different point of view and information to share. Visitors can be prompted to exchange information from each in order to piece together a bigger picture.

- Personalization: One of the most important parts of a digital experience is personalization. All users like the idea that the story is personalized, nonetheless it has not been proven yet that personalization really made a difference. Designing for personalization should always include: recommended choice (e.g., annotate with a star), pace controlling (hurry up, skip, replay buttons) and a way to request more information (e.g., background, related or nearby exhibits). Carefully selected time-estimation & planning mechanisms e.g., Time-based adaptation only in case of hard constraints should be provided, as well as options, possibly different versions of the same story, to accommodate for visitors with different availabilities in time.

### 2.4.3 Summary

Today, the presence of mobile technology in cultural heritage, regardless of its form, is a “must”. It improves users’ experience, nevertheless mobile technology poses some challenges that a designer should be aware of. Mobile usage in heritage sites is a complex procedure. CHESS, a related to our work research project was presented and its findings enriched our knowledge regarding mobile as a tool in cultural heritage.

Personalization is considered as one of the most important factors. The visitor should feel unique during the experience, that she is the center of attention and that her needs and requirements, for example time constrains or interests, have been taken into account. Personalization also needs to be dynamic and highly targeted through levels of information and a careful appreciation of visitors’ age and development. The personalized experience may be facilitated by further control of content delivery, visibility of story structure and explicit identification of content as essential or secondary and loosening of the connection between the physical environment and content where the link is not essential.

Finally, since location-awareness is another aspect of this research, CHESS project provides us with important information on how to conceive user physical presentence inside the museum.

## 2.5 Tangible Interaction in Cultural Heritage

Another less common approach of digital cultural heritage is tangible interaction. In the next section we discuss the interaction based on a tangible object and related work is presented for a better understanding.

### 2.5.1 Introduction

The “information over object” approach has influenced the use of digital technology in cultural heritage ever since computers started to populate the exhibit floor. Tangible interaction takes advantage of the physicality of an object and the functions that can this object serves. Smart exhibits that make it possible for the visitor to feel the heritage and for staff to convey the values of their institution are now under a research scope.

Whatever the form of heritage, some physicality and materiality is usually more conducive to social enjoyment and sharing. Science museums exploit tangible and bodily interaction as an effective way to engage visitors to explore concepts, ideas, and objects. More traditional museums tend instead to showcase multiple historic or artistic artifacts, and “handling sessions” are special events limited to objects that can sustain being touched. Indeed, preservation concerns may prevent heritage artifacts from being experienced in a tangible way, although the importance of tangibility and physicality is recognized. A further way to engage visitors is to diversify the offer on the basis of different audience types—in other words, to personalize the visit using a physical object [14].

Research on tangible, embedded and embodied interaction has meant a shift in approaching such design: from targeting separate devices that are interspersed within an exhibition (whether mobile visiting aid or interactive desktop-PC stations) to creating visitor experiences that are more fully integrated into an exhibition and that extend and complement its materiality and design identity. However, networked objects and the Internet of Things are seen by museums professionals as long term and tangible interaction has been tested in museums only as part of research projects [2].

The term tangible interaction is considered as an umbrella term encompassing “a broad range of different systems and interfaces relying on embodied interaction, tangible manipulation and physical representation (of data), embeddedness in real space and digitally augmenting physical spaces” [11]. A classic form of tangible objects is “smart” objects. They are often derived from existing cultural heritage objects, either original physical objects or copies of them that are augmented by digital technologies. In the case of such copies of original cultural heritage objects, we can refer to them as smart replicas.

In summary, tangible interactions in museums seems to be highly evocative and able to engage visitors in a deeper and more intense way. However we should notice that the physical element is not enough and a direct connection between what the visitor touches and the context is important.

Technically, the digital enhancement can be implemented as technologies that surround the object (external interaction) and technologies embedded in the object (internal interaction).

External interaction places the exhibits within a space enhanced by technologies and makes the surroundings interactive. Examples of such spaces are reactive projections that illuminate and bring to life specific elements, or dynamically generated sound and audio content to attract the attention of passing visitors or to create an atmospheric soundscape.

On the other hand, artifacts, such as replicas of artwork or historic objects, can be digitally augmented by physically embedding into them a computing device (e.g., microcontroller, phone) as well as sensors and actuators that enable (internal) interaction.

By augmenting exhibition artifacts, we take advantage of the engaging power of the physical object, enriching it with the new opportunities that arise from digital media and smart technology [14]. The challenge is to design the computing device in a way that: 1) fits multiple objects in size and shape, 2) includes customized sensors and actuators, and

3) plays back content according to the concepts of the curator. Hardware platforms such as Arduino, Gadgeteer, and Raspberry Pi may serve as a starting point, but much work is needed to create hardware and software toolkits that lower the threshold of use and allow interested parties to create digitally augmented artifacts with only minimal technical knowledge.

Tangible interaction by its physicality offers an important aspect in a heritage experience; the personalization. Personalization can occur at two levels: personalization of content, when different content is offered to different people or presented to offer different interpretations; and personalization in context, when the decision of which snippet of content to deliver and how is made on the basis of the current situation. It is essential to design technologies that are as easy to use and that support the curator to gather and compose content into a compelling storyline.

Developing tools that enable non-technical users to create such complex interactions requires first establishing what makes for a successful exhibition, which content is more interesting for which people, as well as which interaction mechanisms are more engaging and for whom. We then need to establish an understanding of modalities and structures of interaction that can be captured in templates available to curators to populate with content and create interactive exhibits.

### 2.5.2 Prototyping Tangible Interaction

Prototyping is not a new idea. In computing, prototyping has been discussed since the early ‘80s and physical prototyping is as much a core part of traditional industrial design as it is of the newest service design. Floyd lists exploratory prototypes (informal, offers alternatives, unstructured and messy, used to communicate, to be thrown away); experimental prototypes (a proposed solution to a problem); evolutionary prototypes (appear later in the development and is a nearly-complete system). Hounde and Hill distinguish prototypes on the basis of what they capture and therefore what they can evaluate (implementation, role or look-and-feel); early prototypes focus on one aspect while later prototypes should integrate the three [15].

The faster we make our idea tangible, the sooner we will be able to evaluate them, refine them, and move toward the best solution. So, it seems mandatory for a research the physical fast prototyping.

Time, cost and expertise are fundamental factors for fast prototyping. The possibility to quickly give shape to one’s ideas and try out many options during multiple iterations is an exciting perspective for a designer.

Fast prototyping is distinguished into the tree following types.

- **Embedding**: Embedding a device involves inserting the entire device into a new form factor. By simply changing its context and shape, a device can gain a new interactive, tangible quality while preserving its basic functionality. The main challenge here is to map the controls to provide meaningful interactions, which requires little or no knowledge about the underlying technology.


**Figure 4: Example of an embedded prototype: A pocket-size digital photo frame is embedded in a photo bauble. Image from project: Digital Christmas Memories** [15]**.**

- **Cracking it open**: Sometimes the right technology is just hidden in another case or form. Taking it out of this case and using only the necessary parts in a new context enables fast prototype creation without the need for deeper technical understanding. Thus we create a new device by using some internal parts of an existing one.

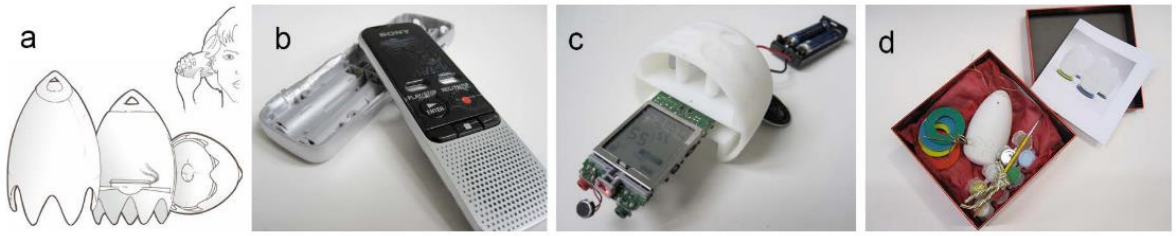



**Figure 5: Example of cracking it open prototype: A Dictaphone provided the functionalities of a sound bauble. Image from project: Digital Christmas Memories** [15]**.**

- **Collating**: Using multiple devices and combining the abilities of different technologies requires technical knowledge but allows us to test various scenarios without expensive, specialized hardware and keeps the design flexible for possible future modifications. Collating involves combining a number of existing technologies or devices to create a single more complex prototype. Some limited coding can also be done in order to create the desired interaction. This is likely to be based on reusing or modifying existing libraries or code that is available online. New code is written only as required by the design process.

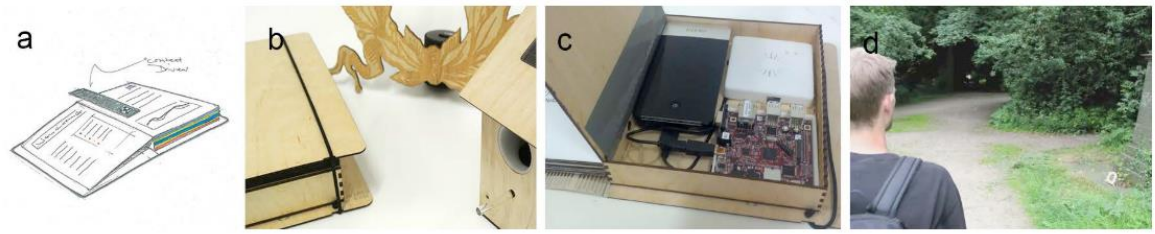



**Figure 6: Example of a collating prototype: An embedded computer and a Bluetooth speaker create interactive location-based audio in the cemetery. Image from project: Interactive Cemetery** [15]**.**

Thanks to previous research on this subject, in order to create a fast tangible prototype a process is proposed. At first, we start by deciding which is the most interesting aspect to explore, as the prototype will focus solely on that. Then, it is time to make the selection of existing technology. This step requires much comparison and some decision-making that will affect the prototype. The next step is the form of the idea. Although some ideas may have been sketched at concept generation, the final form has to take into account the technology. The main issue is likely to be how to map the intended interaction onto

the device controls. An interesting phenomenon in the designing of the form is the inspiration that comes when facing technology constraints. Finally, as always an evaluation step should take place and trigger reflection on what works and what needs reconsidering.

### 2.5.3 MeSch project

A very important EU project in tangible interaction which contributed to our work with its finding is MeSch (Material Encounters with digital Cultural Heritage, http://www.mesch-project.eu). We chose to focus on a specific series of work done in the War Museum. Between 2013 and 2016 the War Museum was part of the European project meSch.

The meSch project aims at creating new experiences for cultural heritage visitors by bridging the gap between the material collection and the digital content via tangible and embodied interaction [14] in novel ways.

The meSch approach is grounded on principles of co-design: the participation of designers, developers and stake-holders into the process of creation and evaluation as equal partners, and on a Do-It-Yourself philosophy of making and experimenting. The meSch consortium consists of twelve partners from six European countries and is coordinated by Sheffield Hallam University. The project – funded by the European Community's Seventh Framework Programme "ICT for access to cultural resources".

During the collaboration between the War museum and MeSch, three exhibits were developed: The "Objects tell a story", the "Voices from the past" in fort Pozzacchio and the "Voices from the Trenches" of the First World War. Role of the War Museum was to collaborate in the testing of new technologies to communicate with visitors and to gather information for the effectiveness and applicability of the devices prepared by the project.

#### 2.5.3.1 Voices from the Threnches – Outdoor experience

"Voices from the Trenches" was one of three exhibits of War Museum and comprise the outdoor experience of this project. The tangible interaction was based on a device which offered visitors a form of tangible interaction to control their experience (Hornecker and Buur, 2006). Two studies were run due to the improvement of the tangible item.

The first trial was tested at the trenches of Nagià Grom from the 21st-25th July 2014. Companion Novel, a multi-point auditory narrative system, was designed by the meSch team at Sheffield Hallam University for amplifying the emotional and interpretative dimension of the visit of outdoor heritage sites with particular historical and emotive values.

The Companion Novel prototype is based on an interactive book-like device that visitors carry with them while walking the ground; the book is complemented by a set of Bluetooth speakers located at points of interest (hotspots) and used to play relevant content. Each point of interest is marked by a sound lantern that conceals a loudspeaker, together with the electronics needed to control it and communicate with the tangible. When visitors approach a point of interest, the Companion Novel recognizes the loudspeaker, connects to it through Bluetooth and uses the strength of the Bluetooth signal to infer the visitors' proximity to the point of interest.

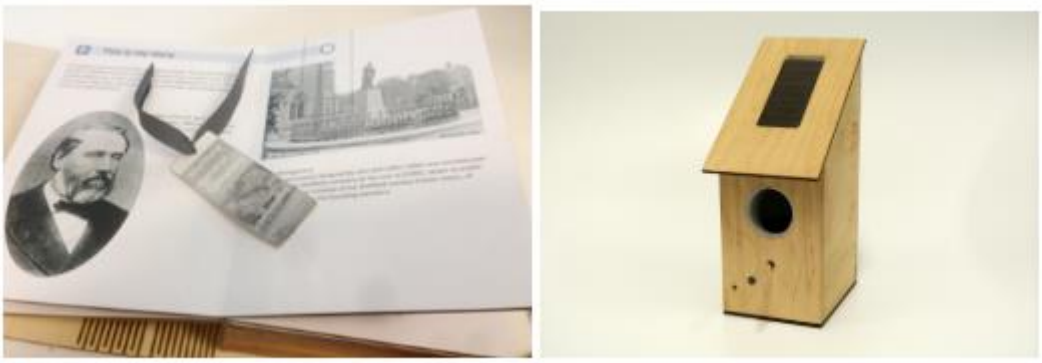


**Figure 7: Companion Novel and bookmark (left), Loudspeakers (right). Image from project Voices from the Threnches, MeSch.**

The content is location-dependent and is organized into different thematic threads that the visitor can select by changing the position of a bookmark in between the pages of the book. Each page of the book corresponds to a different genre/theme or story related to the WWI trenches of Nagià Grom, such as camp regulations, letters and diaries from the trenches as well as war through the eyes of women and poems.

The second version of the system features a different encasement for the companion device carried by the user, a belt with multiple pockets. The belt was inspired by WWI military cartridge belts and disguises the technology for tracing visitors' proximity to the lanterns and choosing the most appropriate content to play. The theme selection which was supported in the book by the bookmark, it is supported here by illustrated cards augmented with NFC tags. Cards could be inserted in and slid into one of the belt pockets. Both the book and the belt-based versions of the system were tested in the field tests at Nagià Grom.

**Figure 8: The interactive belt (center), the soldier's equipment that inspired it (left) and the NFC cards – back side (right). Image from project Voices from the Threnches, MeSch.**

## Findings

Key to the experience was the seamless interaction: the system automatically reacts to the presence of the visitors (by means of the belt they are wearing or the book they are holding) and their movement. The automatic start of the attraction sound first and the narrative after was appreciated by every-one. The voices had a strong evocative effect.

The social dimension of sound in place is equally important. When compared with a traditional audio guide, which uses headphones or a small speaker held close to the head, the sound lanterns produce sound that is shared among the visitors. The visit becomes a social experience. Rather than being isolated by headphones users are sharing the visit with the others that are with them.

Referred to narratives, their importance to the appreciation of the heritage should not be underestimated: only the remains of basic structural work of the camp and trenches are left to be seen. The power of narrative in place was amplified by the performance of the actors in reciting the scripts. The connection made by the narratives with the locations was much appreciated by those visitors who knew the area, such as the references to villages and peaks. It was observed that personal motivations and identity can shape the visit and there is a significant value of designing the narratives to complement and explain the landscape. In the interviews, a need to take away a personal “souvenir” of the experience after the end of narratives was expressed.

Important to the overall experience was the possibility for visitors to choose what to listen via the NFC-enhanced cards or bookmark, a deliberate choice that does not expose the technology, as the material used (paper) does not feel digital or technological in any way. The use of tangible interaction enables to hide the technology from visitors. The visitors interact with seemingly non-technological artefacts: a belt and some cards, a book and a bookmark. While this mechanism gave visitors the possibility of choosing and interacting, it did not distract from the listening experience and complemented the body interaction with tangible aspects. The choice of the theme via card was also designed to be social, the decision to be shared by the group of visitors. We observed group members looking at the cards, discussing the themes and negotiating what to play next.

This project also allowed examining the emotional effect of such a system, and the potential for an emotional connection between the visitors and the heritage site. There is a strong link between sound and emotion, a link that is used to great effect in sound design for film and television; there has not been much between sound and emotion, a link that is used to great effect in sound design for film and television; there has not been much investigation of the use of this in cultural heritage. Yet many heritage sites have the potential for a strong emotional connection between the visitors and the place, but the use of sound in traditional audio guides does not work at an affective level.

#### 2.5.3.2 Voices from the past in fort Pozzachio – Indoor experience

“Voices from the past” in fort Pozzachio constitutes the indoor experience of the collaboration between the War Museum and MeSch project. It took place between October 20 and November 14, 2015 at the artillery section of the Museum. In 2016 a revision of the technologies has been realized and installations have been made permanent.

With devices developed by Sheffield Hallam University and Fondazione Bruno Kessler, the Museo della Guerra has been able to enhance their tour for visitors by offering in-depth information on the impact of a fort built by Austro-Hungarians on the eve of the Great War on the inhabitants of the region. The focus of the exhibition is on telling stories of inhabitants’ lives using meSch technology in order to increase the awareness of the importance of cultural heritage of small communities. The aim of this interactive exhibition is to complement factual information (offered by the museum through guiding material, captions, panels and photos) with digital information related to personal stories, making the visitors feel involved in an emotional experience.

The case study took place in the Artillery section of the Museo della Guerra, located in an air-raid shelter from the Second World that was excavated into the hill over which the museum castle was built.

The topic of the case study is fort Pozzacchio, an Austro-Hungarian fortress of the First World War. The fort was built by the Austrians starting from 1912; it was entirely dug out of the stone and in the last years it was the subject of a large restoration operation. Within the Artillery section, by means of 4 interactive installations placed alongside the cavern, the visitor was given the possibility of listening to the voices of various people who worked or fought in the fortress and whose lives had been somehow influenced by the constant presence of the fort.

At the entrance visitors receive an activating object (a 'pebble') that they can use to activate content at the interactive stations in the exhibition. The visitors can choose which story to listen to and also the order in which stories are heard. The "pebble" was designed to be small and easy to handle. It contains again NFC technology in order not only to activate the interactive stations but also to collect and log data on the stories that the visitors choose to hear. Each station has multiple personal stories on the same theme. The stories are drawn from diaries or memories written during the wartime years or from oral witnesses' accounts made over the distance of time. The narrations are introduced in chronological order. We chose to present the content to visitors in different ways according to the place where the stations are located: videos without audio, audios with or without the support of images and videos of actors performing in scene costumes. The check-in station serve as an introduction to the exhibition to allow an immediate connection between what visitors have seen in the museum and the specific historical topic they are going to encounter in the exhibition at the Artillery.

At the second station the narration was concentrated on the particular construction of the fort; the visitor can choose from 5 narrations by people who worked at the fort. The third station is dedicated to the voices of the civilian population and to the impact of the fort on their lives. At the fourth interactive station we decided to use diaries of soldiers from the opposite armies talking about the same battle that took place in fort Pozzacchio. To reproduce an atmosphere of intimacy and to create a straight connection between visitors and witnesses, we asked the actors to perform while looking into the camera. When leaving the visitors hand in the 'pebble' at the check-out station and receive a personalized postcard.

A final sentence invites visitors to connect to the museum website to find the stories and the bibliographic references of the original documents from which the narrations where extracted. The goal was to reinforce their positive attitude towards the experience, favor memory and sharing, and enable further curiosity and exploration.


**Figure 9: A point of interest in Artiglierie exhibition. Image from MeSch project.**

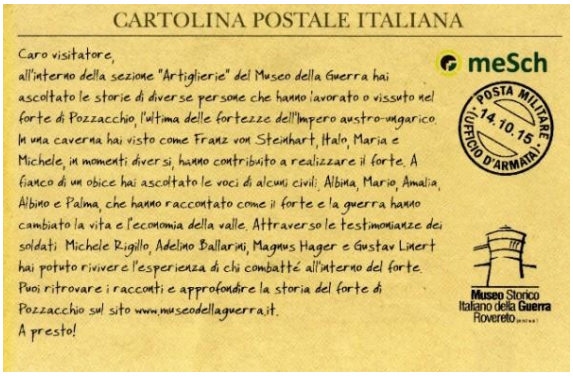



**Figure 10: The personalized post-card given at the end of exhibition. Image from MeSch project.**

From the 20th of October to 14th of November 2015 a visitor evaluation study took place. The general research questions concerned the combination between digital information and museum spaces with “difficult” physical environment; the adequacy of digital content to create immersive experiences that preserve the central role of a cultural site with a strong physical and historical identity; the possibility to use tangible interaction to favor a personal connection and involvement with the exhibition; the effectiveness of the tangible interaction in shaping the experience for small groups.

### 2.5.4 Summary

In this section, tangible interaction, a new research area on digital cultural heritage domain, was presented. Including physical objects into a digital heritage experience may increase visitor’s interest and engagement.

As it was proven by the MeSch project, tangible interaction personalizes better the visit at indoor and outdoor heritage sites and stings visitor’s interest. This new type of interaction is a kind that the visitor is not yet used to it. However, tangibles due to their physicality they are easier to use even by non-familiarized with technology people.

In digital heritage, we have to admit that the mobile’s dominance is huge and, as it has been stated in previous sections, mobile screens rule visitors’ experiences in cultural heritage experiences. Hence, using tangibles as part of a heritage experience seems a clever, convenient solution that will take visitor’s interest from the mobile screen to the artifacts. However, we have to mention the danger of further user disorientation from the heritage because of the tangible.

In summary, the personalization that physical items offer to user experiences perfectly matches with our work goals. Tangibles inside cultural heritage augment a heritage experience without the obvious/visible presentence of technology. This is an aspect that we want to take advantage in our experience and contribute to tangible research.

## 2.6 Storytelling

Storytelling is a powerful tool of digital cultural heritage, which enables heritage to get rid of her informative character and make visitor feel during her visit. Storytelling improves user’s experiences but not all stories are fascinating. In this section, we try to understand what makes a good story and how to use storytelling to profoundly engage the visitor.

### 2.6.1 Definition

Storytelling is deeply embedded in human learning, as it provide an organization structure for new experiences and knowledge, recognizes that across cultures and over time, people can mentally organize information better when it is recounted in the form of a story. According to story theorists like Bruner (1991), stories provide a framework for

making sense of events and their meaning. Stories carry large amounts of information in a compact format [4].

Despite the power of a story, not all stories are designed to engage the listener. There are some characteristics that improve a storytelling experience and touch emotionally the people.

### 2.6.2 Storytelling for Cultural Heritage: Requirements and Challenges

Storytelling applications for cultural heritage share the characteristic of active users, who walk around in a physical place (mobility) and act upon technological devices that bring their own limitations into the interaction with the user. In particular, it is important to keep in mind that, in cultural heritage, storytelling holds informative goals.

The requirements of digital storytelling experience are separated to spatial and temporal. Spatial is referred to being aware of the visitor's location during the visit and delivering appropriate content for the location, taking into account the topological structure of the site and the possible path of visit and temporal to constraining the visit to finish within a certain amount of time, possibly imposing a duration to some subparts of the visit.

From all the above requirements, some challenges are deriving concerning a storytelling experience in a cultural site:

- Interactivity: Linear storytelling must cope with this challenge, devising ways (such as metaphors and plot devices) to turn potential inconsistencies introduced by interactivity into elements of the story.

- Mobility: Site topology and mobile technology constrain the design choice.

- Informative goals: The storytelling application typically fulfills other needs than user engagement in a story. In cultural heritage, most applications, independently of the paradigm they adopt, have the primary goal to convey information, even when the entertainment finality is outstanding (Reid et al. 2008).

- Technology and settings: Again the site topology, the hardware and software specifications of the mobile device, the participating institutions, all introduce additional constraints to the design of a storytelling digital experience. The device, being primarily a communication and computing device, brings with it a suite of functions and technological constraints the storytelling must cope with, such as modality, supported media, etc. Different storytelling applications rely on different media contents, depending on the degree of intended intrusiveness, on the need to preserve the users' focalization or drive her/his attention. Finally, the constraints posed by the cultural heritage curators to the use of technologies on site are also very relevant to shape the applications.

The mobility and interactivity requirements of the users challenge the fluency of storytelling, setting the need for solutions that provide:

- Location–adaptive selection of the narrated facts, so that the storytelling application is aware of the visitor's physical presence in the current location;

- Story synchronization with the visitor's progression through different locations, to form an overall consistent narration.[16]

### 2.6.3 Digital interactive storytelling in cultural heritage

In human–computer interaction, the design of sophisticated characters has proven to be effective in improving the naturalness of the interaction between software systems and users, making systems appear more responsive and cooperative.

Nowadays, the focus in digital heritage sites and especially in museums is shifting towards the use of artefacts for providing an interactive experience to visitors, in contrast to the traditional museum approach, where the focus was on the collection, display and storage of objects. More visitors searching for entertainment, as many it was referred in precious sections the main motivation of a heritage visitor is not learning.

Digital technologies, in particular interactive storytelling, have a great potential for assisting both the education and entertainment of visitors. This is because they can communicate the heritage of societies in an interactive way; overcoming some of the problems presented by more traditional means, such as text. General visitors' desire instead broad understanding and informal learning so they gaze in observation mode focusing on pictures and sound first and text last. Moreover, technologies can provide personalization and contextualization of the information delivered to the visitor providing advantages, such as visitors learning at their own pace. This is important as visitors to museums have particular requirements, hence their behaviour and attention is different in the museum environment.

The most common conception of story is a linear sequence of scenes, a very common structure that we meet in movies or books. This type of storytelling is already popular in museums, allowing stories to be presented not only of artefacts, but also of people who lived through more recent episodes in history. Thus, storytelling in museums is mostly linear and only partially interactive.

According to literary studies (Prince 2003), storytelling develops along two orthogonal axes, which characterize each story: characters and plot. The plot contains a series of incidents, made of characters' actions and unintentional events, connected through a causal chain [16]. In interactive storytelling, artificial characters have a twofold function: On the one side, they are the medium through which the story is conveyed to the audience, since they perform the live actions that make the story advance; on the other side, they are the necessary condition of the interaction with the user, since they provide the interface between the system and the audience.

Interactive storytelling can exploit digital technologies to provide a new level of engagement within collections, exhibits and even locations. Interaction between the visitor and technology can enhance the interaction between the visitor and her surroundings. Nowadays, digital technologies give the opportunity of more sophisticated nonlinear stories; allowing visitors to interact with the story at different points in time. For example the ART-E-FACT project [13] which introduced Mixed Reality interactive storytelling with virtual characters, positioned next to real art pieces in an exhibition, discussing art, while prompting visitors for their opinions and questions. The Dark (http://www.thedark.net/) gallery also delivers audio content to visitors according to their position in a physical darkened space. While, the NICE project developed an application for museums to enable youngsters to have multimodal conversations with 3D animated fairytale author Hans Christian Andersen (HCA) and his fairytale characters.

The pilot Interactive Environment [13] was evaluated to find out the acceptability of visitors to the overall experience as well as the usability of the system. The findings concerning the interactivity, the story content and the use of technology sum up at the graphs below. The overall study brings out the importance of interactivity and technology in museums exhibitions. People enjoy a well-structured, simple and short story as well as the gamification. The topic of a story is more important and personalization, as stated before, arouses user's interest. Technical problems are always expected and can turn the experience less immersive.

### 2.6.4 Emotion – Driven digital interactive storytelling

Interactive digital storytelling has attracted a great deal of research interest in recent years. However, most interactive stories are told following a goal-oriented and task-based mode which motivates the player to interact with stories by achieving the goals rather than empathizing with the characters and experience the enriched emotions. The way that a story evolves the user is driven by the goals. In order to achieve a goal, a set of tasks are structured by generating a sequence of actions. Therefore, the motivation of interacting with stories primarily comes from competing with others to achieve these goals rather than empathizing with the characters' experience to enrich emotions and to guide the story development accordingly.

Given this fact, a new direction of digital interactive storytelling experiences is conceived based on Smith and Lazarus' cognitive theory of emotion; an emotion-driven interactive digital storytelling approach. Smith and Lazarus argued that our experience of emotions and our responses to them changed dynamically with the situation we found ourselves in. Furthermore, they argued that behavioral responses would not stop the emotional experience, but continuously influence the subsequent appraisals and emotions leading to new actions [17].

Therefore, in emotion-driven approach, the user's emotions are put in center and motivate the story forward and contribute to their experience directly and explicitly. The aim of the emotion-driven interactive digital storytelling approach is to allow users or players to adapt narrative storylines in accordance with their experienced emotions.

The series of emotional responses of the user player direct the narrative and determine the final 'story' they experience. In this sense, different players would experience different stories based on their different emotions evoked by empathizing with the characters. Emotions, thus, become a powerful driving force for personalization of interactive experiences, a factor always requested in experiences of this type.

In the cultural heritage context specifically, attention to 'what visitors feel' has been highly confined. Here, emotionally-evocative interpretation is almost exclusively limited to 'dark', 'difficult', modern or historic subjects, especially those related to trauma and extreme suffering from the recent past. Premodern and prehistoric heritage rarely feature in these initiatives. Moreover and unsurprisingly, best practice guidelines for achieving such impact are focusing on the provision of first-hand testimonials, speeches, photo/filmic evidence, oral histories and memories, sources that can enable visitors to directly access the real 'lived' experience. As no such documentary sources exist for the prehistoric context, and as some archaeological sites (not to mention intangible heritage) may have little to no visibility today, these guidelines have debatable relevance. Thus, no coherent framework of practice (neither a conceptual model, nor practical guidelines) yet exists for designing and evaluating emotive experiences for the cultural heritage sector at large [18].

Findings from previous work concerning an emotion-driven storytelling experience based on a TV series [17] revealed that user experience of emotion-driven storytelling is impacted by the different player types (i.e. male vs female) and their preferences for different media (digital games vs traditional narrative media). This idea has also been stated before by psychological research. In general, females feel more emotional involvement and empathy than males and those who like traditional media entertainment, such as TV and film, get more pleasure from interaction than those who like playing digital games: importantly, these findings have since been confirmed in convergent quantitative research carried out in the laboratory.

### 2.6.5 EMOTIVE project

Emotive is an EU-funded heritage project that aims to use emotional storytelling to dramatically change how we experience heritage sites. EMOTIVE creates digital cultural heritage experiences in different and challenging sites as Çatalhöyük, a prehistoric civilization or the Ancient Market of Athens, a heritage site where all artefacts are strictly intangible.

For heritage professionals, the Emotive application provide a powerful storytelling engine and a set of rich digital media assets that can be used to create detailed characters and narratives featuring archaeological sites or collections of artefacts.

For visitors, Emotive offer dramatic, emotionally engaging stories that can be experienced while at a cultural site or remotely. Wherever visitors are, they can follow characters, look for clues and explore environments alone or with family and friends.

The EMOTIVE project main aim is the design of digital experiences which seek to:

- adopt a story-based rather than an object-based approach, supporting interaction between (virtual) characters as well as real visitors, as well as engagement with the objects;
- blend the online with the on-site experience;
- seamlessly integrate the pre-, during, and post-visit activities, and the intangible with the tangible;
- cater to the dominant visiting patterns of museums and cultural heritage sites, which primarily see groups of visitors participating in social experiences with varying - sometimes conflicting - individual motivations;
- integrate exploration of hybrid 2D/3D spaces in meaningful ways which support the storytelling and the social and emotionally-engaging experience of the visit.

Since EMOTIVE research is at its beginning and the evaluation framework is under development, the results are not clear to come to conclusions. However, this work shows the need of informative storytelling to change and to bring the visitor in the center of experience [18].

### 2.6.6 Dramatour methodology

Dramatour methodology [4] is another way to make much more engaging a storytelling experience. It provides a framework for developing mainly dramatized guided tours. Dramatour methodology is a methodology for information presentation based on drama in character-based presentations. The working assumption of the Dramatour methodology is that a character, who acts in first person and shares the visitor's present time and space and yields a powerful effect of physical and emotional presence. This form of storytelling is found in between interactive and emotion-driven storytelling.

The methodology relies on three major tenets. First, the dramatized presentation, acted by a character, is authored in a specific layout for mobile devices, and is accompanied by the design of a specific strategy of interaction with the visitor. Second, the presentation is factorized into semantically tagged audiovisual units. Third, these units are edited on-the-fly during the visit, in a way that accounts for adaptation and interactivity.

#### 2.6.6.1 A stroll with Carletto the spider

A stroll with Carletto the spider [4] is an example of Dramatour methodology implemented for a museum purposes. The application has been developed for a historical site and is based on a virtual character, "Carletto", a spider with an anthropomorphic aspect, who

engages in a dramatized presentation of the site. Content items are delivered in a location-aware fashion, relying on a wireless network infrastructure, with visitors who can stroll freely. The selection of contents keeps track of user location and of the interaction history, in order to deliver the appropriate type and quantity of informative items, and to manage the given/new distinction in discourse. The communicative strategy of the character is designed to keep it believable along the interaction with the user, while enforcing dramatization effects.

The goals of this work were:

- As a mobile application, to bridge the lack of any visit infrastructure (labels, marked paths, etc.) the device (and the character on it) follows the visitor through her changes of location, and compensates for the missing facilities by providing the visitor with contextual information.

- As a storytelling experience, to add a “touch of theater” to the visit of historical locations, by delivering a dramatized presentation aimed at giving the visitor the impression of being a guest in an inhabited place.

The application follows a location-adaptive based on:

- Sensing. The changes in the visitor location are actively monitored by the system to identify the appropriate content to be delivered and the depth of presentation, which depends on the visitor location and on the duration of the permanence in that location.

- Decision. The Interaction Manager determines the next communicative function based on the interaction script, given the interaction history and the visitor input (localization and explicit input).

During the evaluation of Carletto the spider different finding were gathered. Significative correlations showed that visitors with high education level are more critical about the experience with the character of the story, in particular with the content quantity and the dramatized presentation. Visitors with high education level are not inclined to assign the personality of a “wise” to Carletto. However, young visitors identify the main character as a “travel mate”, while young visitors who do not appreciate Carletto do not like his extreme curiosity. In general, young visitors are likely to assign a positive evaluation to a device-driven museum visit, like the audio-guide.

Focus on storytelling part and drama-based tour, visitors who generally appreciate audio-guides have also a positive attitude toward Carletto. It is possible that these visitors do not like a social dimension in the visit, and they are likely to be alone in experiencing their visit. Moreover, as the age level decreases, their preference toward such devices tends to increase.

### 2.6.7 Summary

In summary, storytelling is a known old tradition by which knowledge is transferred. Especially in heritage places where history is one of the main aspects, storytelling often is used to inform visitors for its background and history. Although informative role has never been an attraction for the visitors, on the other hand interactivity often is. To turn a story of cultural heritage into a notable story for visitors appears a lot of challenges that we discussed on this chapter.

During the last years, there is a shift from simple or interactive storytelling experiences to emotion-driven storytelling. Based on various studies, it is established that emotions and responses to questions related to emotions can integrate dynamically the user into the

heritage experience. However, creating a story for prehistoric or premodern heritage sites is not an easy process due to lack of first-hand information about these periods.

In the last part of this chapter, related work such as EMOTIVE project and Dramatour methodology has been presented. Drama-based stories put the user in the center of the experience. Research results are very promising concerning the engagement of user by these approaches even though this part of storytelling is not studied intensively and the current projects are on the first stages and evaluation methods are not completely developed.

In this project, we aim to move the user and her emotions right into the center of experience. We care about user's emotional status each moment during the storytelling and we strongly believe that it consists of a considerable factor of an immersive digital heritage experience. Hence, emotion-driven storytelling is an aspect that we want to adopt to our work.

# 3. DESIGN

## 3.1 Introduction

In this section we are going to discuss the designing choices of the project, used in the design and later in the development of the experience. In the first parts, we present two important features of the designing process; the key idea and the addressed audience. While designing this project, we elaborated two different approaches of a digital heritage storytelling experience. Each one of those is described analytically in the next chapters.

## 3.2 Key idea of experience

As we have stated at the beginning of this project, our goal has been to design an experience that combines cultural heritage and technology. We attempt to create a different form of a heritage visit using relevant details collected by related work presented in the previous chapter. As an extensive designing procedure, while designing, we followed the bodystorming [19]. Designing for heritage is designing an experience in a particular context, and it is necessary to discover and consider all its aspects while designing for this specific space.

Related projects, like CHESS, discussed in the previous chapter indicated to us the value of narration-centered digital heritage experiences. Of course, there are many points to overcome regarding this method. We do not want to create another audio guide or an experience with the exclusively didactic character. To elaborate on this idea, we will also take advantage of emotion-driven storytelling, a state-of-the-art methodology in this area. The key idea of this project is to place user's experience in the center of design and create stories that will enable users to feel closer and engage with the heritage.

Secondly, in digital storytelling heritage experiences, the principal role of mobile is still maintained. Strongly inspired by MESCH project, we want to introduce to our embodied experience the physicality of tangible interaction. The association of these two forms determines a lot of additional factors to consider while designing, however, the final result should be characterized by its simplicity.

## 3.3 Personas

Before jumping into persona's details, it is important to shortly describe the heritage site where our project is going to take place; the Ancient Agora of Athens. The location of a heritage site and the ambient environment are closely connected to and influence a person's experience.

The Ancient Agora of Athens is also well-known as the Ancient Greek Agora. It is located in the northwest of the Acropolis and it is called Market Hill ("Agora"). The Agora's initial use was for a commercial or residential gathering place. As a cultural heritage site, it poses a great research interest because it combines outdoor and indoor spaces.

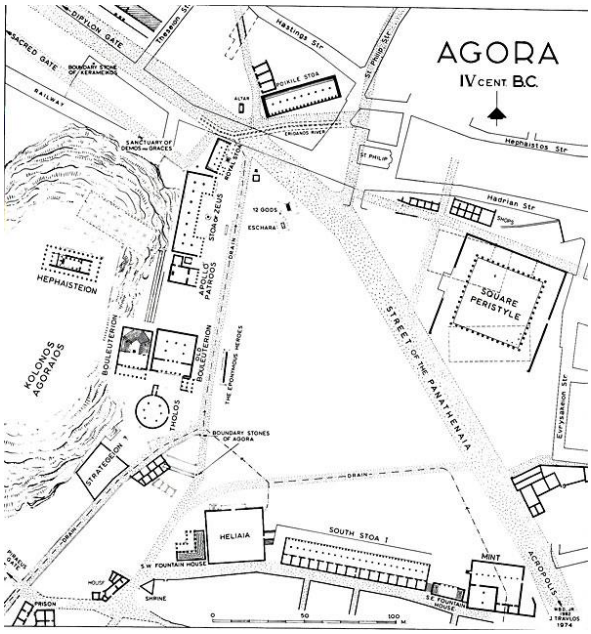



**Figure 11: Map of Agora of classical times. Image from: http://www.agathe.gr/**

At the Market place, there are 20 buildings and structures of classical times, as well as more than 14 notable monuments of this era. If we wanted to make a separation of this location, we would divide the area in 2 parts: the outdoor and the indoor part. The indoor location is an old gallery, the Stoa of Attalos, which now serves as the museum of Ancient Agora. The outdoor location has an exceptional character due to the fact that the place used to change in different chronological eras. The remnants of the buildings from classical years are not well preserved. The preserved outdoor heritage is mainly buildings' foundations and a temple which can be visited only from the outside. In contrast, the indoor heritage is very rich. The museum possesses multiple collections from various eras. However, similar to what happens in most of the museums, the heritage is intangible and the knowledge behind the artifacts even though rich and long, it is not properly displayed.

Ancient Agora is a place where great personalities, like Pericles or Socrates, lived and orated. Hence, it is a place highly visited by millions of tourists throughout the year. To explain our personas, we split the users/visitors into two groups regarding their visit's traits. Our primary users are people who cannot engage with the heritage through ta simple visit, nevertheless we should examine the reasons why these people visit or not a heritage site.

The first user group that we should consider while designing this experience, is the locals, the people that they come from Greece, they live in Athens and they have the option to visit the site whenever they desire. We also have to analyze a little bit further the attitude of Greek visitors in cultural heritage sites. Regardless of how many years pass by, Greek visitors are a museum visitor's category rare to find. In the Ancient Agora and in other archeological sites, the majority of native visitors are groups of schools and in less common cases families with young children. Even though in Greece, archeology is a very famous science and the ancient monuments and museums are highly appreciated by Greek people, as part of their identity, there is an intense distancing from heritage by the latter. Greeks mostly visit museums during their school years and after that people tend not to visit museums or art exhibits. There is an identification between heritage and effort to gain knowledge that deters people from visiting museums. The local audience often feels detached from cultural heritage and thinks of its sites as places where they have no connection with or/and as places of something old-fashioned that brings boredom.

On the other hand, as it was stated before, Ancient Agora has a great tourist audience. Its location, below Acropolis Hill, as well as, the personalities connected to this place turns Agora to a popular tourist attraction. Nowadays, the majority of Agora's and Agora's museum visitors are mainly tourists in groups or individuals. However, visiting a heritage museum as tourist is often an understood obligation. In particular, these visitors are more commonly accompanied by a tour-guide or they just walk around the sites, watching. Agora's infrastructure cannot support all kind of visit types. We have to take under consideration that the heritage is intangible and in many cases un-stewarded. The majority of these visitors leave the site fascinated by the site, but completely disengaged.

This project values the personal motives of each visitor, yet it aims to discover a new approach of visiting a cultural heritage site. Through this experience, the relation with cultural heritage sites and museum should be revised. It is an effort not to hide the informative traits of this place but differently handle them through technology and engaging storytelling. Of course the experience can be used by whoever wants to discover Agora's history in a different way.

### 3.4 Requirements of the digital experience

Knowing that a lot of people avoid visiting museums and heritage sites because of the difficulty to find the proper information about artefacts and sites, we have to establish some initial requirements of the designed experience in order to give it a first form. Each described requirement derives from a need of our future users.

Firstly, focused on the Ancient Agora's site, either in the indoor or the outdoor area, there is a great number of artifacts with a rich historic background, but the information provided by tags or maps is considered poor. The artifacts in some cases can be very similar or regarding the outside area there are mainly buildings foundations. Therefore it is hard to distinguish and locate the heritage for a no well-versed visitor. In fact the majority of visitors use tour guides to visit Ancient Agora. Hence, to design a digital heritage experience in the Ancient Agora requires the adaptation of localization technologies on our interface.

Secondly, the developed experience should treat with the gap between visitors and heritage. Since the heritage is not well preserved and mainly it is intangible, it is difficult for the visitors to feel close to the artifacts and "feel the heritage". They mostly feel indifferent during their visit. This attitude requires something more than a digital company during the visit. The experience has to increase visitor's interest and to keep her highly motivated during her visit. Thus, interaction seems an essential attribute of this design. The user should feel that she has the control of her visit.

### 3.5 First design of digital heritage storytelling experience

The first attempt to design a storytelling location-aware experience was placed on the outdoor area of the Ancient Agora.

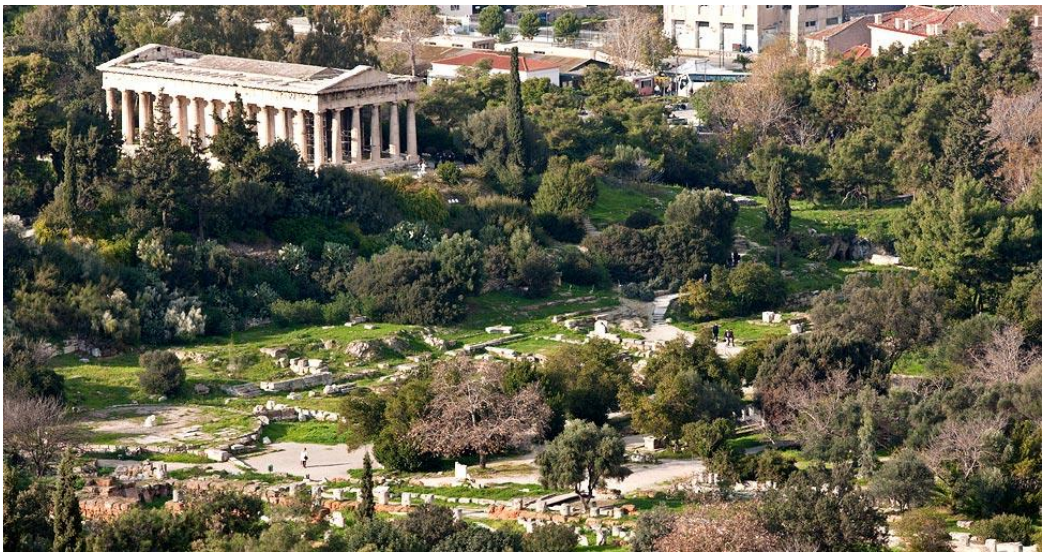


**Figure 12: Outdoor area of Agora**

The main idea of this approach is that the visitor follows an interactive story spanning across a large space of the outdoor space of Agora. The narration is the center of the experience while the interaction consists of some branching points which are closely connected to characters emotions. Agora was the center of Athens and several functions of ancient Athens are found in this place. The information is given indirectly, like in a movie. The visitor takes the role of the main character and follows him through his adventures. The branching points of this story are related to the character's emotions. The visitor can customize his character and his adventures by choosing. In this chapter, the scenario and story's characters are presented. The scenario is a work of Katerina Servi. In the next part, the developed interface is described, as well as the findings collected from a heuristic evaluation that we ran in situ.

### 3.5.1 Characters

The use of characters increase the naturalness of interaction and makes the users to feel more attached to the storyline. Each character carries its own pre-story which could help later on the narration. Furthermore, the characters that have been designed for this story have particular functionalities of Ancient Athens. This helps visitors to better understand the people that lived during this era. It seems like a method to bridge the gap between now and then.

In the list below we present the main and the supportive characters of our story.

**Main character – Hermeias**

A slave in Athens of 398BC. He likes the family that he belongs to and regularly visits Ancient Agora to make the grocery shopping for the house and learn the news. He doesn't know his family, but he owns a necklace that he supposes that it comes from his family.

**Nicoclis**

Hermeias's owner. Works at Tholos of Ancient Agora as an administrative employee. He is kind and respects his slave Hermeias.

**Galateia**

Galateia is a hetaera that uses to visit often the market place. Heteara was a famous occupation in classical Athens. Women of this class were well-educated and free. They could handle their finance and have property. Galateia has also a slave Argeia. She is supportive and always helpful.

### Eukratis

Eukratis is a strict and tough man. He is weapons' constructor and money lender. His store is located on the Hill of Ifaistos, near Ifaistos temple.

### 3.5.2 Scenario

To create a responsible interface, after presenting the characters we have to specify the scenario of this storytelling experience. The main idea of this scenario is that the visitor follows Hermia's character through his daily life in Ancient Agora. In several and important points of the story, the visitor is called to make a decision for Hermia's life. These decisions affect the storyline and change the end of the story. This method help user feel that she has the control of the story and create a more personalized experience.

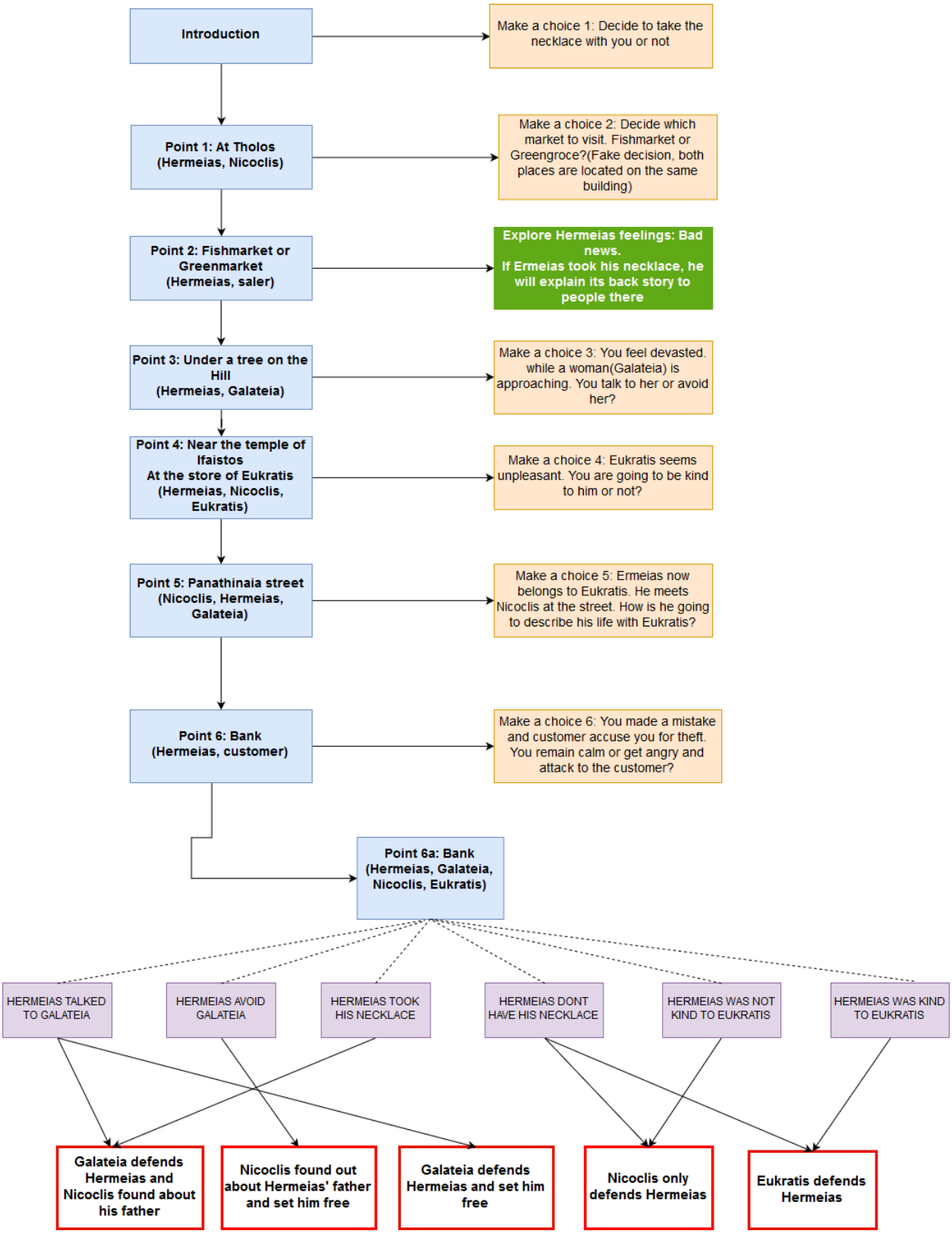
The scenario of the story is organized into chapters that represent days of Hermeias' life. Each chapter is connected to a place/building of the outdoor Agora along with a character. During the story, the visitor listens to Hermeias' problems and his dialogs with others. Through the story, the characters and the functionality of related buildings are presented so as to help visitors to keep in touch with the daily life of the location. The place acquires a meaning through the people and the story.

Hermeias owns a special belonging, a necklace which affects the storyline. In the start of the experience, the visitors have to decide, as being in the shoes of Hermeias, if they want or not to take the necklace with them to their "trip" at the Agora.

The questions/story's branching points are closely connected to the emotions of the slave Hermeias and by extension to visitor's emotions. The visitor is desired to feel close to Hermeias and make decisions for him. When the visitors are called to make a decision, Hermeias' emotional state is given. This story designing was made to turn the story more emotive. Hence, we pay attention to the characters' feelings and let visitor choose "from her heart".

Below we are going to present a tree that describes the storyline and the scenario. Blue boxes are the chapters of the story that take place in specific locations. The red boxes on the right indicate the branching points. On the bottom of the graph, the final boxes suggest the possible different story's conclusions related to different user's choices. The green right box is a possible effect of a previous choice on the scenario of current chapter.

**Table 1:Hermeias story tree**




### 3.5.3 Design of Interface

To create and design the interface of the storytelling experience, we used Storyboard. (http://athena.emotiveproject.eu/dev/sbe/#!/editor) Storyboard is a tool that helps users with no-technical background, such as writers, to easily create storytelling experiences. These stories can be previewed on computer screen at any time and when the final story

is ready, the story can be exported to the “Narralive” application. Then, the users can have direct access to the story by using the application.

Storyboard is a writing tool designed for users without any technical background. Therefore, it is a simple high-level tool that can be used to easy design storytelling experience. It offers various types of screen layouts and the option of branching.

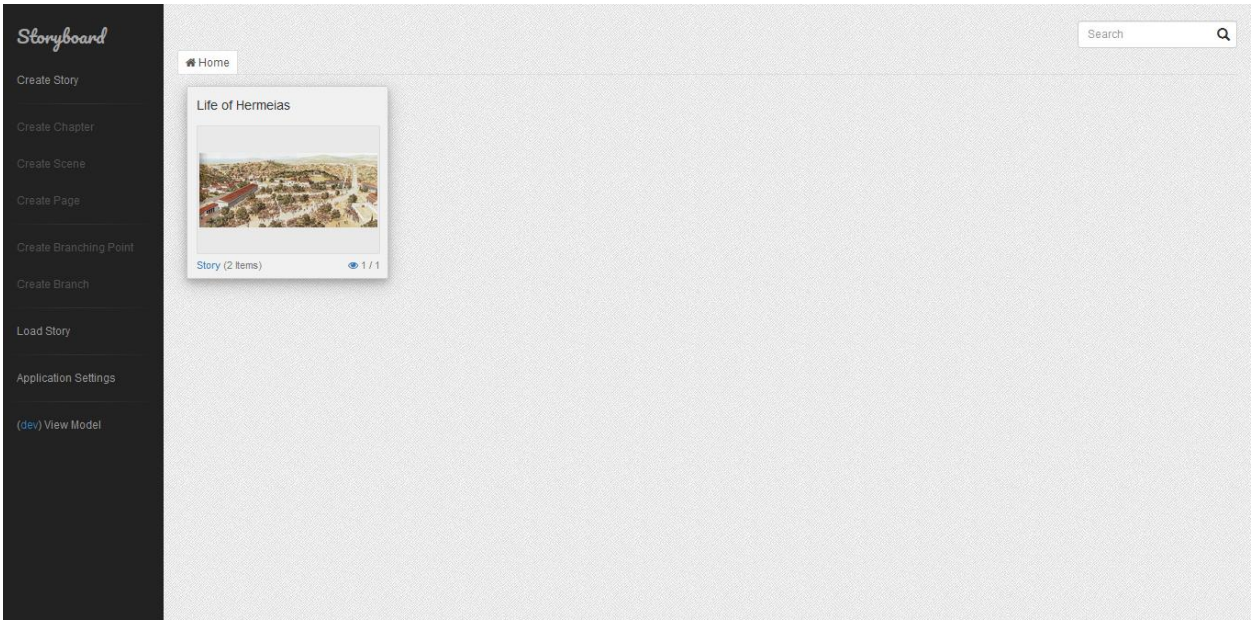



**Figure 13: Storyboard Interface after a story’s creation**

A storyboard’s page can be a simple page with combination of text, audio and images. For example for the introduction of Hermeias character we created the following page.

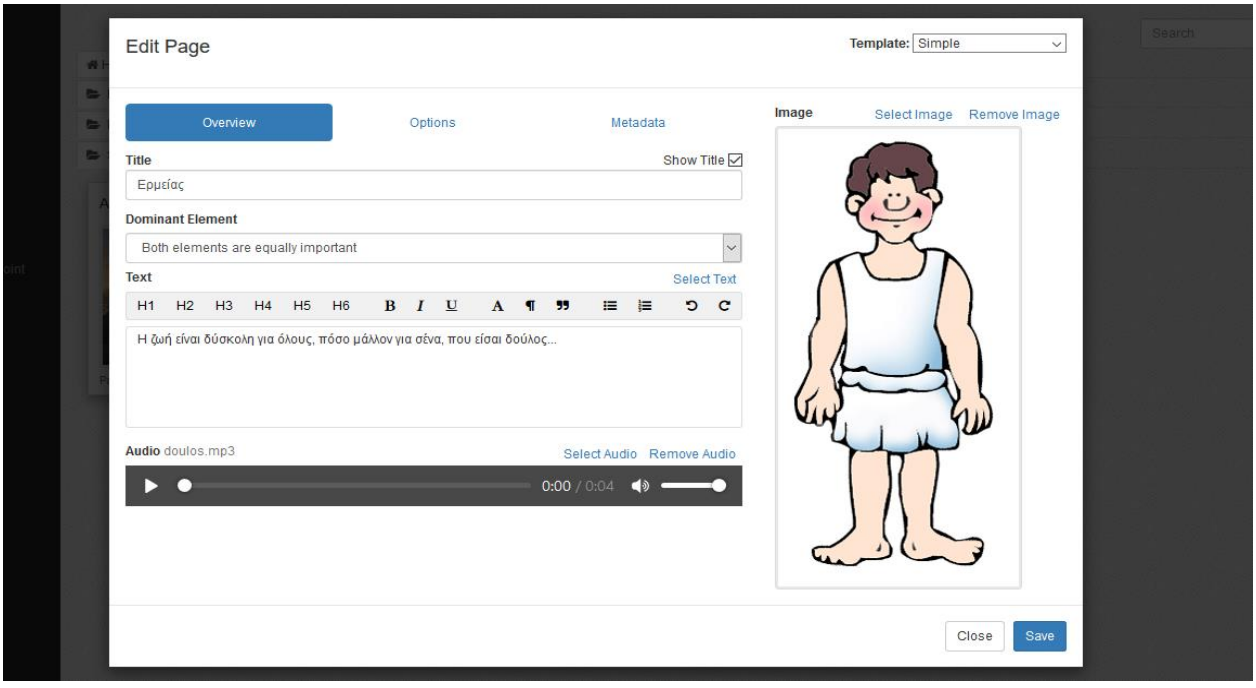



**Figure 14: Storyboard interface to create pages with text, photo and audio**

Moreover, via Storyboard we can create pages that have dialogs, questions, NFC reading or video display. For the purpose of this project, we used branching, simple pages and dialogs.

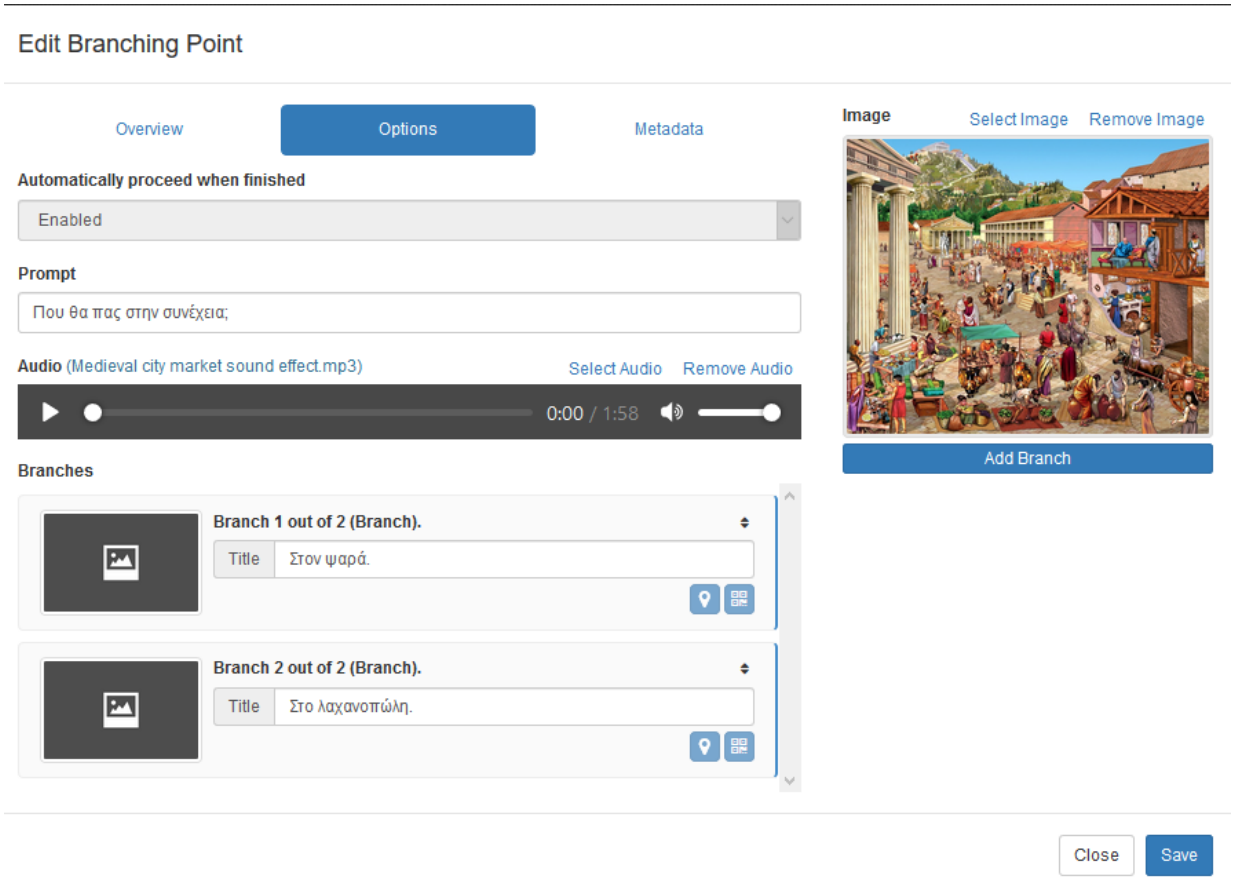



**Figure 15: Storyboard's option to create a branch**

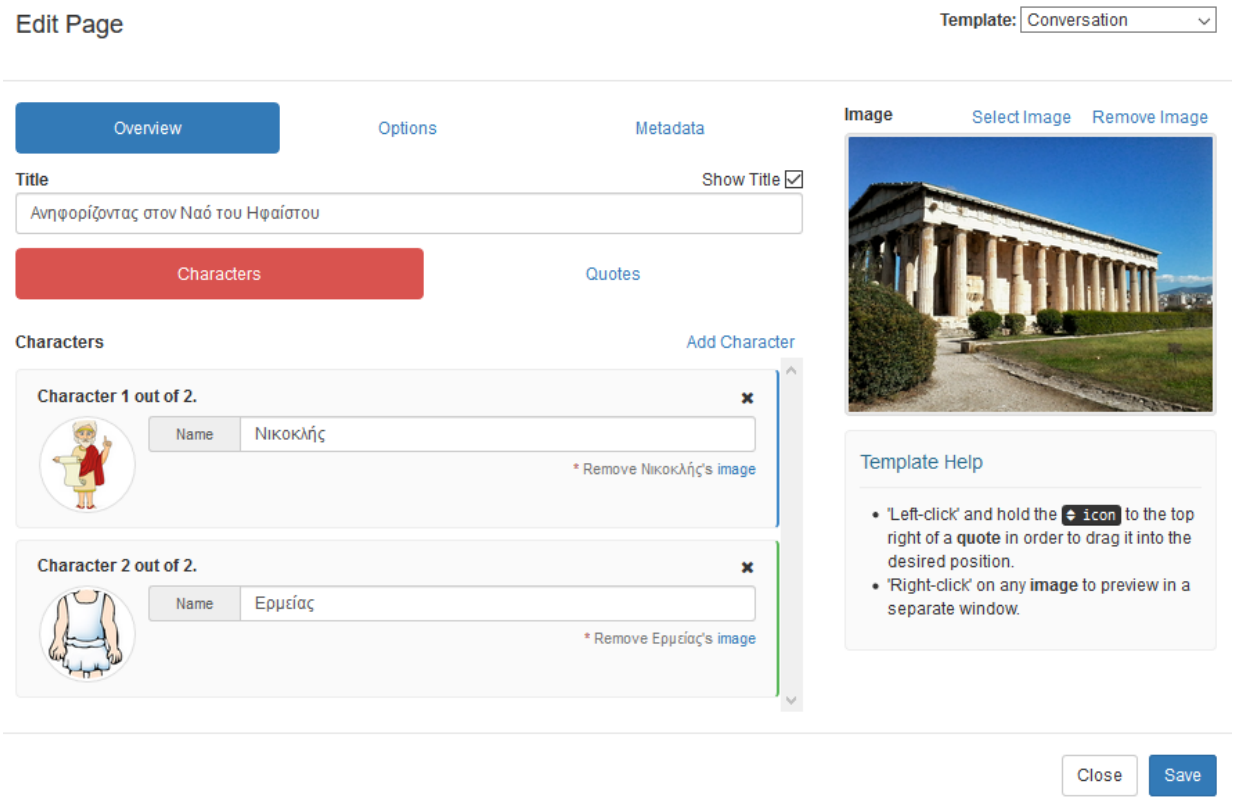



**Figure 16: Storyboard option to create dialogs**

Since the scenario of our story is ready, we created and uploaded the story of the Life of Hermeias to Narralive. The story was designed to be used at the outdoor Ancient Agora. On the next part, basic screen views of story's parts are present.

For Hermeias story we based our design on dialogs and simple narrations accompanied by photos. We choose to show photos of the site as it is supposed to be back in classical years. The site is un-stewarded therefore we need material to support user visit and introduce her on story context.

The screens below are the introduction chapter to Hermeias' life story and to the total storytelling experience. These screens are supposed to be displayed at the entrance of the Agora area, while the audio sets the historical context and the respective timeframe. As a consequence, the story integrates gradually the user in the Agora of 398 BC.

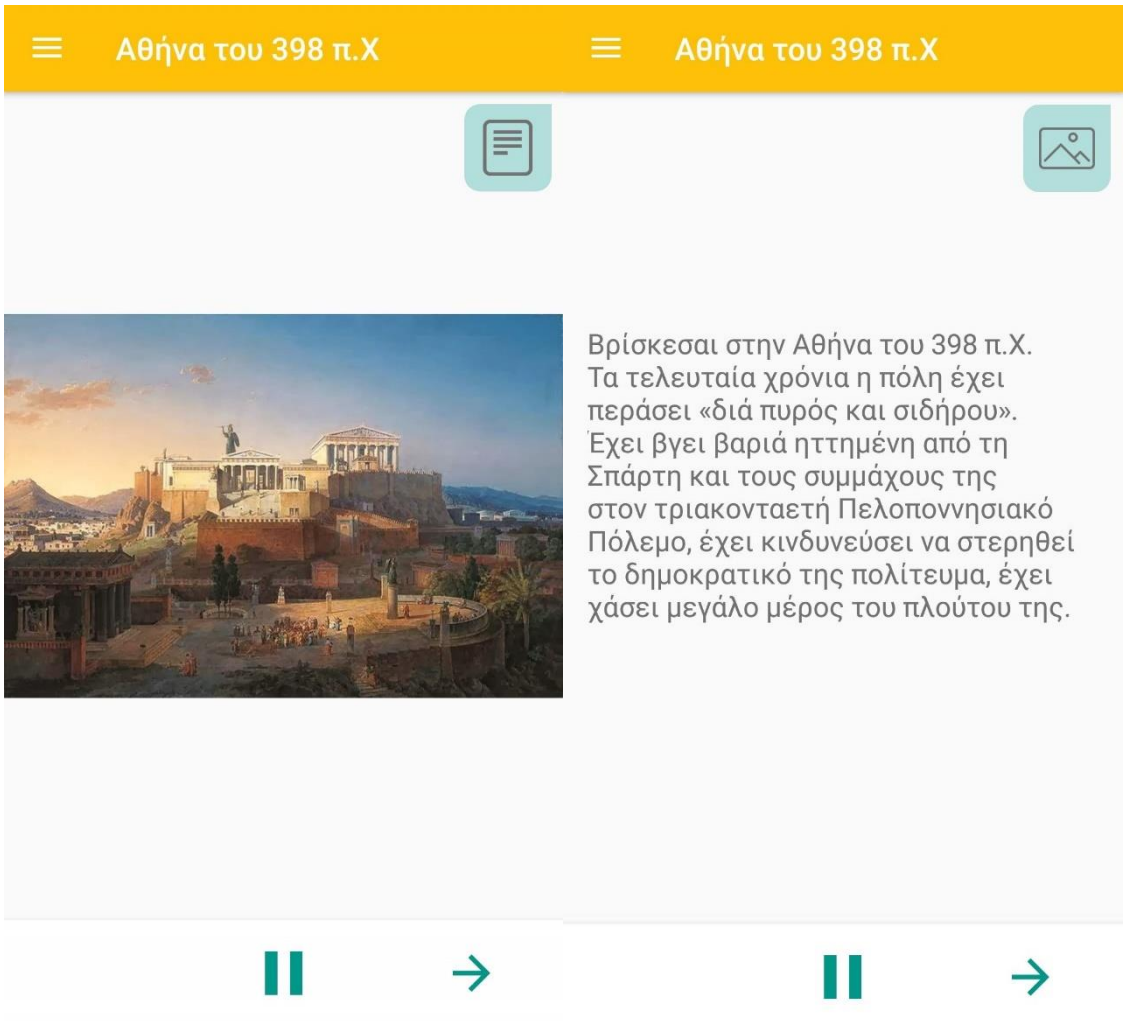



**Figure 17: Introduction screens**

After the introduction, the main character Hermeias, is also introduced to the visitor. As the visitor meets Hermeias, he learns also for his story and his necklace. The first branching point takes place concerning whether Hermeias should take the necklace with him or not. The presentation of necklace and the branching point are shown below. Photos are used to turn the whole object more real.

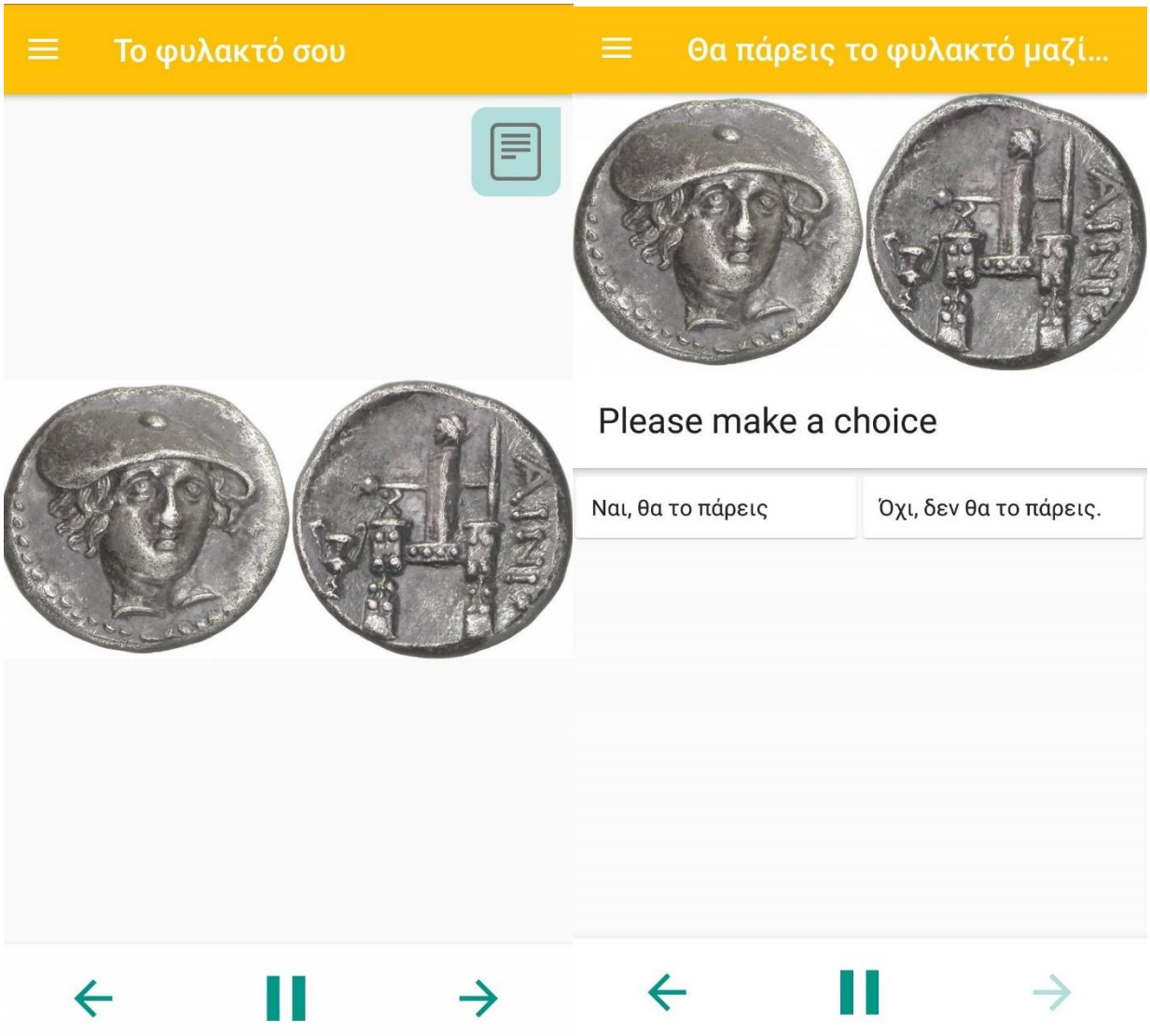



**Figure 18: A branch of Hermeias story**

After the decision regarding the necklace, the visitor starts to walk. Ideally the application should localize the visitor and play each part of the story when the visitor is near to a point of interest. However, since we are on a designing stage we used the wizard of Oz technique [21] to implement the localization technic. When a visitor was near a certain point, we informed her to proceed to the next story. On each chapter, photos of the location where the chapter take place are displayed to maintain an accuracy between the story and reality.

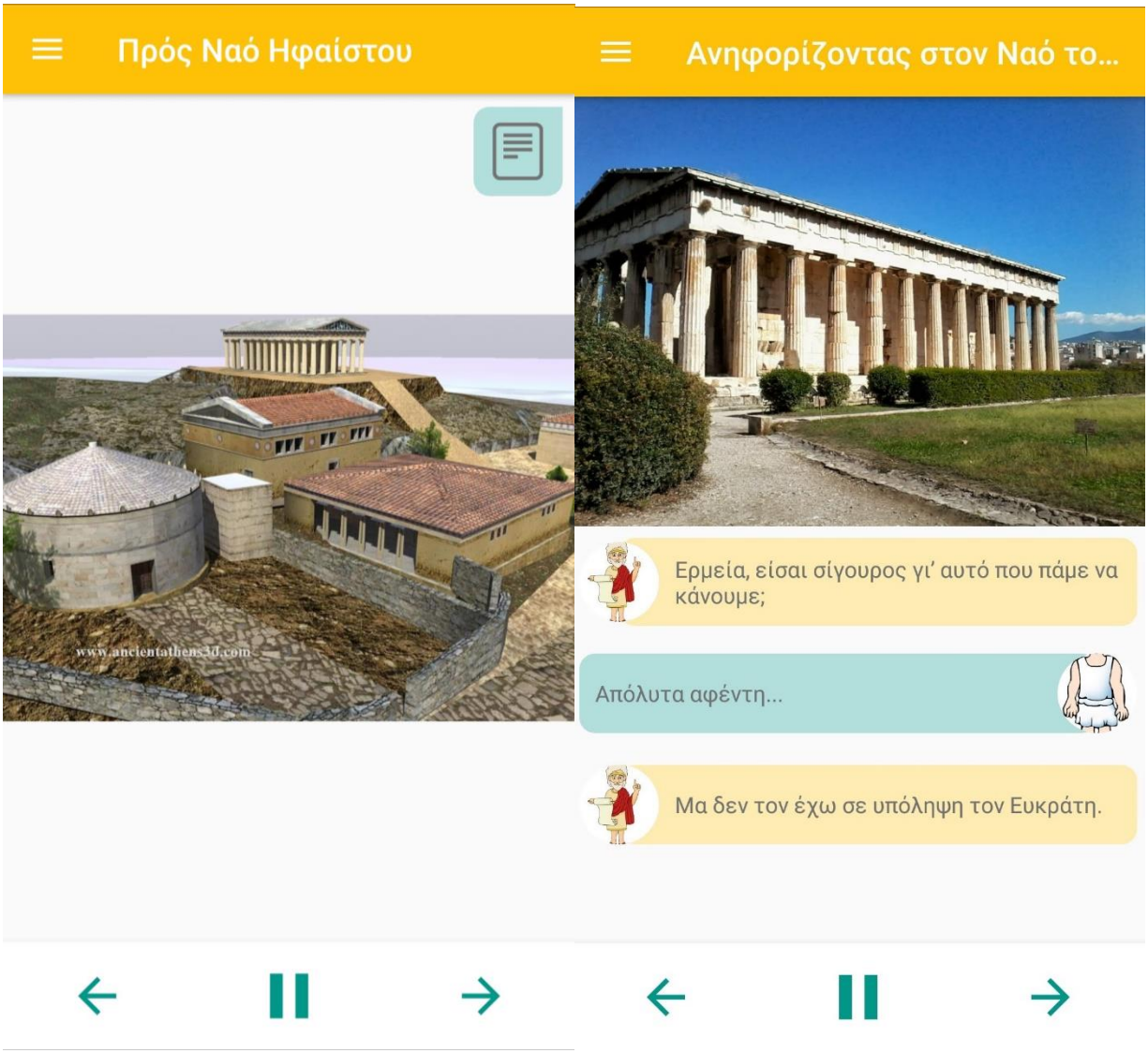



**Figure 19: Screens of Chapter on Ifaistos Hill location.**

The screens above show how we tried to improve user's wayfinding without adding further questions, for example "Are you here?".

During the walking time between stops or between dialogs, ambient sounds were used to make user to better anticipate the place.

The trail of Hermeias and the visitor inside the Agora is a circle. The final chapter is placed near the museum of Agora, at Vouleutirio. In this part, the application asks the user if she wants to remember more facts about her life as Hermeias. Positively answering this question will drive the visitor inside the museum and present more chapters about Hermeias life in Ancient Agora. For our design, the procedure stops at Voleutirio.


**Figure 20: Conclusion of Hermeias Story**

### 3.5.4 Findings

A formative evaluation of the storytelling experience that we designed was run in situ by a multidisciplinary team; the author of the story and two researchers, in order to receive an initial feedback.

It was found that the story absorbed users who easily followed Hermeias through his adventures in Agora. It was observed that each user took her time to complete the story and sometimes they were listening again the dialogs. One user at the end of the experience stated that it would be nice to sit and listen to the story before proceeding to the next stop.

The use of ambient sounds during the story narration, such as sounds of the marketplace while Hermeias is at the fisherman's store, received positive feedback in contrast to the ambient sounds in between points of interest. Even the user who stated that she enjoys these sounds, after a while she paused the audio. We suppose that this is because it is an outdoor location and too much sound may disorient users.

The trail was easy to follow using the "fake" localization. Hence, there is a highly need of user localization in experiences similar to this.

The story and its content were appreciated by the users. Even though the main story was found interesting by everyone and the questions gave to users the feeling of participation, users did not develop great levels of empathy and affiliation for the main character. Moreover, whether there were branching points, the story seemed to users as too linear. As one user stated “I feel that I liked the story because it was outside. If the same story took place inside a museum, I would be bored. There wasn’t enough interaction”

Thus, the results of this trial seem promising concerning the better engagement of users. However, more interaction is needed than a simple question related to the storyline. Also, we believe that the story shall take into consideration about characters’ emotions and during its narration, any dramatic effect had a major influence to the formation of the final experience.

### 3.6 Second Design of digital heritage storytelling experience

Due to technical reasons, the second and final attempt to design a user interface for a digital heritage storytelling experience was held at the indoor space of Ancient Agora, the Agora’s museum. Since museum’s space is smaller than the outside, it would be easier to control the implementation and more convenient to develop a design that tests our initial goals.

For the second designing of the storytelling experience in Ancient Agora, we decided to change the previous concept of storytelling and approach the heritage through the stories in a different way. This new approach is considered to avoid the intense informative character of the heritage site as it gives an aspect of gamification to the experience.

We observed that people got more easily connected with an object when they learnt the object’s backstory by a person who is connected with it somehow and especially when the story punctuates the emotion state of these characters. In case the object is an artefact, we suppose that the visitors would feel more attached to it if they hear its story by a relevant person. This approach influenced the creation of a new story scenario and the designing of a second heritage experience anew.

#### 3.6.1 New story and Characters

In most of the museums, the majority of digital storytelling experiences focus on a simple exploring of the artifacts. Information relative to the artifacts is always the goal. Either way, the visitor is informed about their history, about their owner and their functionality in the past. In the new story, the need of emotion-driven storytelling strongly remains. Unlike the common storytelling experiences, for this project we want to focus on a different story’s component; the people hidden behind the museum’s artifacts. The history of objects is more or less the history of people that used this object. Do not neglect the fact that, in Ancient Agora, multiple memorable personalities lived and acted there. Thus, it would be interesting to “meet” the people of Agora through its artefacts.

For the scenario of this case, we decided that the artefacts will serve as boxes which enclose various emotions. These emotions represent a short story of people of classical Athens or people connected to Agora’s museum. The presence of a visitor can open the boxes of emotions while each one of those characters will try to narrate his/her story to the modern visitor. In this way, the visitor will see and understand that the objects have a live history behind them.

Another factor that affected the generation of the new story was the way these characters would be used in the total experience. Since modern visitors do not know in depth the Greek history, we found hard for them to connect with personalities that they are not familiar with. By contrast, what people understand and anticipate more easily are the basic emotions. Everyone knows how anger or joy feels. Therefore we decide to hide

each character behind an emotion. Each emotion indicates the way the particular character felt for the character connected to the display case/artifacts. This approach can increase the feeling of mystery in our story.

The characters of the story were designed and developed by the writer and archeologist Katerina Servi. Each one of the museum's display cases is represented by a key historical figure. The characters hidden behind the emotions are actual historical figures or more recent people of Agora, as an archeologist.

In our case, we choose to organize the experience around the artefacts related to Socrates and to a rich pregnant woman. Hence, two stories are produced, which have as key figures; Socrates and the pregnant woman, respectively. The rest of the characters narrate their point of view about the key character to the visitor. Their sayings would be characterized by an emotion. The produced story is not linear; characters operate as story's chapters. Except these characters, the user can hear the objective information about the key figure and the artifacts by the fictional character of Agora.

In the table below, a mapping between characters and emotions for each story is presented.

**Table 2: Mapping between emotions and stories' characters**

| ***Emotions*** | ***Characters of Socrates Story*** | ***Characters of Pregnant woman Story*** |
|---|---|---|
| Anger | Xanthippe | Her husband |
| Fear | Plato | Her midwife |
| Jealousy | Critoboulos | Jealous "friend" |
| Joy | Alcibiades | Archaeologist |
| Admiration | Xenophon | Museum assistant |
| Sadness | Simon | Sister |
| Indifference | Local store owner | Priest |

Further information is given below concerning the characters whose stories are related to the two stories accompanied with the respective emotion and their connection to the display case's character is not clear. In particular Socrates' story presents a lot of historical figures for which visitors are not obligated to be aware of. Agora's character in both stories is the personalization of the heritage site. Agora was always there, she knows everything about everyone. Her story is the most objective and "historical".

### Xanthippe – Anger

Xanthippe was Socrates' fabled wife. They didn't have a good relationship. Their arguments were a very popular happening in Ancient Agora. Xanthippe was always complaining that the philosopher was idle and that he didn't have an important job.

**Xenophon – Admiration**

Xenophon was a famous historian and a student of the philosopher Socrates. He admired Socrates for his calmness and equanimity.

**Simon – Love**

Simon was a very close friend of Socrates. He was his student and he owned a shoemaker's store at the Agora, where Socrates spent a lot of time with him. The items found in Simon's store included the pots from which Socrates probably drank the poison of his execution. Simon was one of the students who wrote down Socrates work.

**Critoboulos – Disgust**

Critoboulos was an Athenian aristocrat. He was against Socrates lifestyle and work.

**Plato – Fear**

Plato was one of Socrates loyal friends and students. He wrote down Socrates' work after his death. Plato was presented at Socrates trial and up to the very last moment he have never believed that Socrates was going to be executed.

**Alcibiades – Joy**

Alcibiades was an Athenian politician, warrior and close friend of Socrates. Socrates was Alcibiades teacher and a mentor for him.

Pregnant woman's artifacts were found recently and the mystery around her grave arouse a lot of reactions. This is why we introduced two modern characters to the scenario to draw the whole image around this case.

Each character's narration aims to last 1 minute approximately.

During a short formative evaluation of this scenario, we detected two possible flows. The first one, which was easy to fix in a later re-design, was the absence of the emotion of apathy. People often feel neutral emotions for other people. Hence, we created the character of a local Athenian and a priest who represents the emotion of indifference.

The other problem of this scenario appears the lack of references regarding the artifacts of the current display case. The user is standing for more than 1 minute in the same spot, listening to stories that are not immediately connected to the artefacts. A better connection should be created between characters and artifacts. For instance, the characters could point out some artifacts during their narration.

### 3.6.2 The interaction: Design of tangible

One important drawback that we detected during the evaluation of the first digital experience that we designed was the lack of interaction and user participation in the story. The storytelling experience was based on a single mobile application. The only active activity, that the user did, was choosing answers on branching points. That approach may work effectively at outdoor areas, but inside the museum, where space is smaller and the size of knowledge is wider, the visit demands more interaction.

Apart from adding more interaction, we would like to turn this digital heritage experience into a more personalized experience. It is not easy for all visitors to empathize with the main character and feel immediately part of the story. We have to create a more personalized experience and by expansion a more personalized story. The user should have the possibility to control the storyline in way that she directly affects the story.

Thus, inspired by the related projects of chapter "Background and Related Work", we decided to add tangible interaction in the storytelling experience. Proper designing of a

tangible could serve as combination of interactivity and personalization of experience. The physicality of tangible can cover the gap between the intangible heritage and the modern user.

The conception of tangible's idea was also based on the lack of physicality that emotions have. It is clear that the storytelling experience that we design, gives a special focus on the emotions. On the last section, while presenting the new scenario of our story, we used emotions to cover the story's characters. Therefore, the tangible of this experience could now serve as a mean that makes emotions more physical.

After the introduction of the tangible interaction's idea, we are going to explain further the scenario of its use, in order to explore its requirements and then arrive to a construction of a fast prototype.

At the start of the storytelling experience, the curators will provide user with a tangible. This tangible will be used in collaboration with a mobile application. The user carries the tangible with her all around the museum. While standing in front of a display case, she can use the tangible to unlock/discover new stories concerning this area. By using the tangible, the mobile application should identify which chapter/emotion the visitor wants to listen. The same tangible will be used in different areas of interest.

From this scenario, multiple requirements derive concerning the design of tangible object and tangible interaction. The requirements are presented in the list below:

- Light – weight object, designed not to give additional weight to the visitor.
- Concept of a special item for the user, something that will trigger user's imagination.
- Easy and clear use. Tangible's design should be able to be reused to other areas of interest by the same user.
- Identification of emotions through the tangible
- Convenient shape in order to embed possible technology.

In order to give a meaning to our tangible and in the same time make it easy to carry around the space, we can give it the form of a necklace. The necklace would be a gift from the Agora to the modern visitor to enable the unlocking of emotions and her communication with Agora's people. For a fast prototype, a light-weight material should be considered.

From the above requirements, we can conclude that, by its design, the tangible should focus on the identification of emotions and clearly separate emotions. To turn tangible into a more special object for the user, we consider a mapping between emotions and colors, using the Plutchik's wheel of emotions. This method allows this kind of distinction between emotions that we intend. Utilizing Plutchik's wheel, the emotions are expressed by multiple color tones. For the user, colors distinguish different emotions and affect the storyline. This approach will help us understand if eventually, in a user-centered design, colors affect user's choices.

In the next graph, a mapping of emotions, colors is presented. The color of each field is accurate towards the Plutchik's wheel of emotions.


**Figure 21: Categorization of Socrates' story chapters by color, emotion and character.**

As soon as we came to a decision concerning the way of emotion's distinction, we have to choose a shape of our tangible. For a simple and fast prototype design, an octagonal shape seems a good solution. The inspiration of design came from the magical necklaces of fairytales. A necklace with an unusual "stone" like a diamond, of 8 colorful sides will be given to the visitors as a mean to interfere to the story by choosing the right side. Furthermore, the tangible is shaped in a way that, the appropriate technology can be embedded later on. The chosen material is hard paper in order to keep the object light-weight.

**Figure 22: Inspiration of tangible. Image downloaded from: https://www.canstockphoto.gr.**

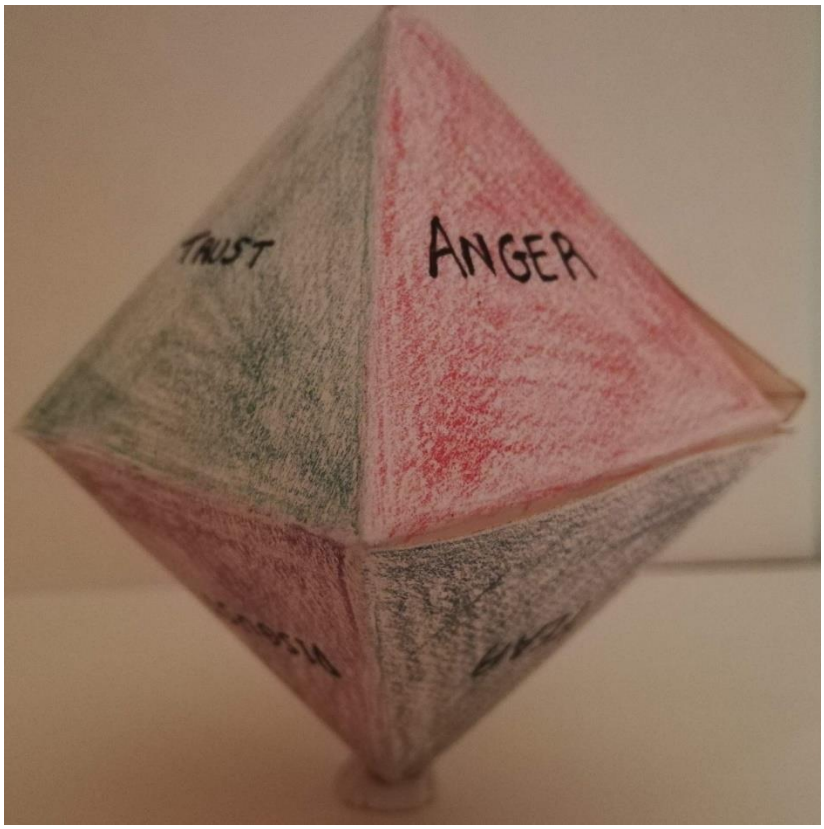



**Figure 23: First paper prototype of tangible**

Finally, in regards to the tangible interaction, we consider mobile user's touch on a tangible's side, as the more natural and direct way of interaction. The smartphone can be used as a mean between the user and the tangible. The technique, Touch & Interact, is recognized for its advantages regarding ease of use, intuitiveness, and enjoyment. [20]

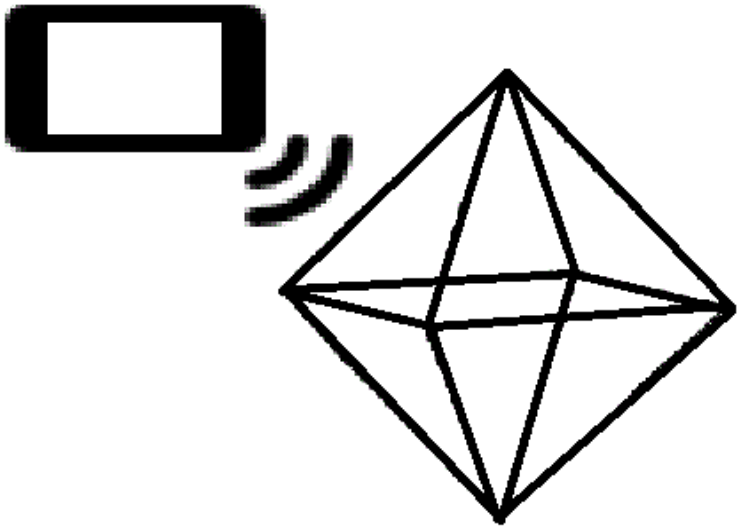


**Figure 24: Designed method of interaction**

The phone acts as an information display and is used to provide additional or more up-to-date information to the user. Specifically in our case, by touching on one side/emotion, the storytelling proceeds with the proper chapter.

Using a mobile device to touch objects in order to interact with them is a relatively new concept related to RFID technologies. This kind of interaction is usually used to interact with augmented books, documents and business cards [10]. Therefore, a big audience is used to these techniques. By providing proper guidelines, Touch & Interact technique can be used even by technology non-familiarized people. Hence, we placed, on the back of the smartphone, the following sticker to let the user know which part of the phone she should use to touch the tangible and trigger the narration of a certain emotion.

**Figure 25: Area to touch on tangible's sides**

### 3.6.3 The interface

The interface of this experience has a twofold character. It should serve as the storytelling interface and in the same time, it should be responsible of the tangible interaction. In general, it coordinates the tangible activity and the story activity. This is a challenge that we kept in mind while designing.

In this section the scenario of interface's use and the requirements of its design are presented. By using these requirements, we created a series of prototypes based on which we can process, in a later stage, the implementation of this interface.

### 3.6.4 Scenario of Use

In order to design the interface of this project, we first have to define a suggested scenario of use and then list the requirements of this design. These steps will help us design the prototypes of this interface.

The scenario of our experience is placed inside Agora's museum.

**Structures and Items of our interface**

Before proceeding to the scenario of use, we have to categorize the items and the structure of the interface that we want to design. This procedure helps the configuration of the final scenario.

The first structure is the specific display cases of the museum which serve as areas of interest. Visitor's "enter" and "exit" actions in these areas should be handled by the interface. The interface should respond accordingly to these actions and specific events will be triggered.

Another important item of this interface is the tangible that was described in previous chapter. The interface should handle the interaction of visitor with the tangible.

A mobile-based application has to serve as user's storyteller guide through the museum and gather all structures related to the experience.

**Scenario of use**

The user enters in the museum and the curators provide her with a smartphone equipped with the right application, a headset and the tangible. The application starts and the user is introduced to the experience by the Agora.

Before starting the main part of the experience, a short training on what is the tangible and how to use takes place. The training concerning the tangible takes place after a greeting from Agora and consists by the following steps:

- Examine the tangible – Tangible's role
- Interaction explanation
- Trial of interaction
- Ready to start the experience

The user has as many times as she wants to examine and familiarize with the tangible and the main idea of the experience. Then, if she feels ready, the main experience starts. A "skip" button should be provided.

The application incites the visitor to start walking around the museum to find areas of interest. If the user feels insecure about where to find these areas, she can choose an option "My trail" and get informed by an interactive map about the specific location of areas of interest. While walking and watching the various artifacts of the museum, the visitor enters an area of interest. She listens to a voice calling her to come closer to the describing display case and on the mobile screen an indication to stop walking is displayed. A way to proceed to the narration part is now offered. In case the user is not sure about the right display case, she can visit the interactive map again where in areas' description, photos can be found.

In front the right glass case the user starts the narration. The voice and the screen text will ask her, what kind of emotion she wants to unlock. It is time for the user to interact with the tangible, as the training taught her.

**Figure 26: The display case of Socrates' story**

**Figure 27: The display case of pregnant woman's story**

While an emotion is chosen, the narration is transmitted via audio and text on the screen. If the user wants, due to external stimulus she can pause the audio and replay it. At the end of narration, the character who was speaking is revealed. If the visitor enjoyed the process, she can try a new emotion choice or if not she can exit the area and search for another area of interest. While standing, in case the visitor lost the track of what she has listened to, she can find her stories collection without exiting the narration state, on an option “My collection”.

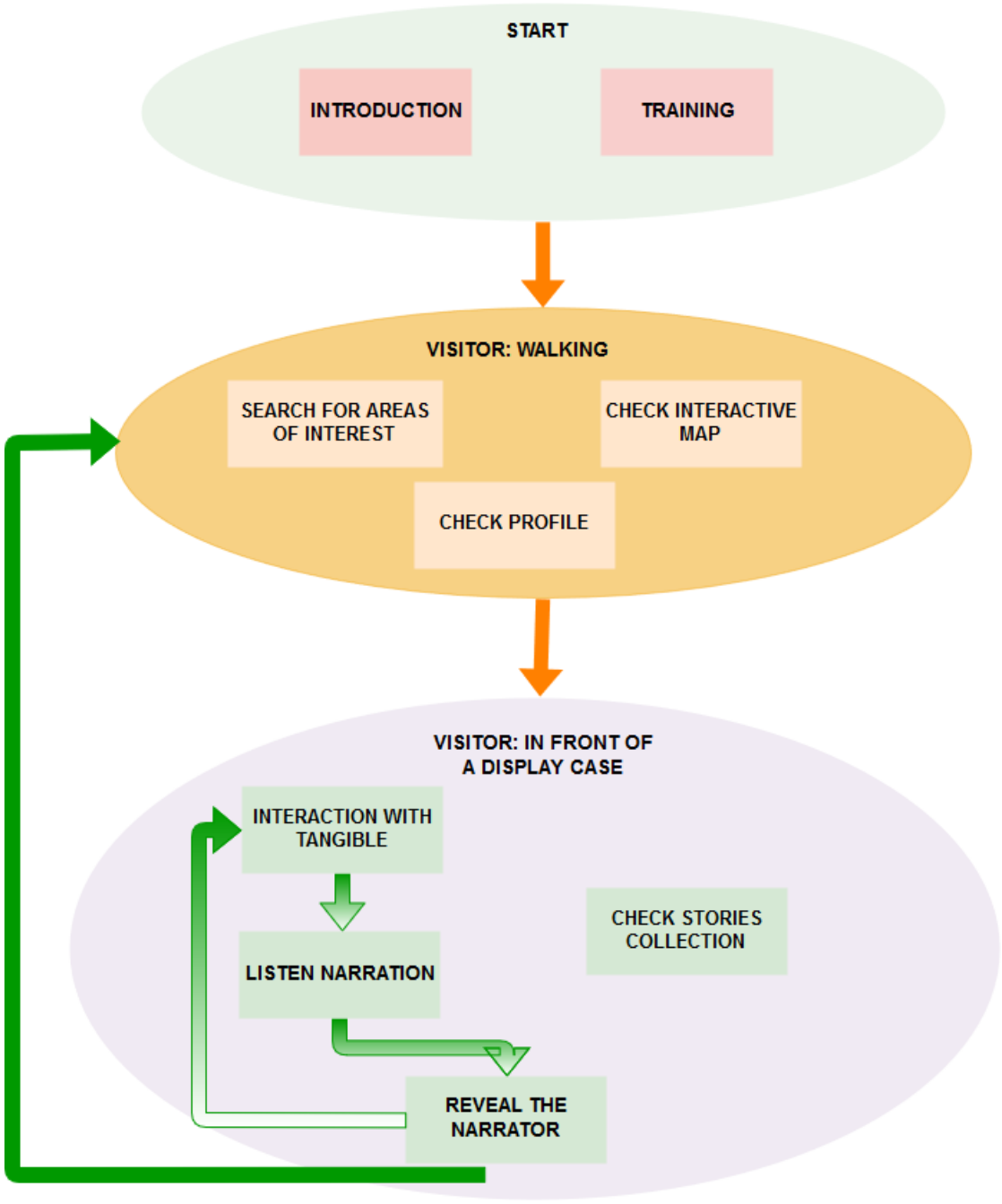
Since visitor finished listening and exits the narration, she returns to the last screen where “walk”/”stop”/”search” orders are given. By this step, an indication of current area’s state should be provided. For example, visited but not done. The visitor can start walking again and if she enters to another area of interest, the same procedure is repeated.

At any time, while user is out of narration states, she checks her profile to find a list of collected stories during her visit. If she enjoyed a story, she marks it as favorite.

In case user discovered all stories or wants to quit the experience, she can exit. She quickly scans the screen of her mobile and finds the exit button “Done”. After quitting, the experience generates visitor’s profile based on her choices during the experience. The result could be shared on visitor’s social media to give the impression of something to go away with.

The following graph presents the states described above.

**Table 3: Stages of user's visit and possible actions**




### 3.6.5 Requirements

Using the scenario of use of last chapter, we can specify now the goals and the needs of a user while using this interface. It is important to mention that through the above scenario we care about the design requirements of the interface and not about the way that we can implement them.

The requirements that derive from the above scenario of use are listed below:

- Easy understanding of tangible functionality and the manner of interaction with it. An introduction to tangible's use is necessary.
- Define small areas of interest and handle of visitor's "enter" and "exit" actions in them.
- Short, straightforward directions about when it is time to walk or stop.

- Access to a map of location
- Keep track of the attending stories
- Provide extra help to user when it is time to interact with the tangible
- Indication about visited areas
- Personalized result at the end of the visit and possibility to share results on social media
- Emphasis on the audio rather than screen text. Visitor should pay more attention to the environment and the artefacts

From these requirements we can infer some specifications for the interface that we want to design. First of all, the interface's design has to be strictly minimalistic. Besides the introduction part, images and videos should be avoided. The interface would display short messages, like orders and audio.

The interface should provide a graphical representation of the place to enhance user's wayfinding. While exiting or entering on areas of interest, audio should be trigger in order user do not feel obligated to always watch the mobile. Interface should have clear implications on when the user has to use or not the tangible.

At the end of the experience, the interface should provide visitor with a personalized result, something that the visitor can take away with her. A solution could be the generation of a result concerning the visit's trail and the possibility to share it on social media. In this way, the visitor will have a unique output of this experience.

The storytelling experience can last from 1 story per display case to as many stories as the visitor wants to listen. If the visitor desires, she can exit the narration part or the total experience at any moment.

### 3.6.6 Prototypes

As soon as we examined the scenario of use and the requirements of interface design we create prototypes of the mobile application which is responsible for user storytelling experience and user interaction with the tangible. The stage of prototyping is one of the most important stages of designing because it helps perceive errors in the early stages of the project. Generally, the prototyping could be high and low level. Since there is a high need for a simple and minimalistic design and we want to focus more on audio with proceeding immediately to high-level prototyping.

Regarding the part of aesthetics, we used blue as our application primary color because it is a color not used to map an emotion.

#### Visitor's state: Walking

When the visitor is walking, we choose to display always a bottom navigation menu where the visitor can switch between screens and find supplementary information about her visit. The default choice should be the option of discovering zones of interest around specific exhibits. While the visitor is walking, the screen serves as a guide, displaying the suggested moves.

In places that no area of interest is detected, the screen incites user to keep walking. In case, the visitor enters an area of interest the application should respond accordingly and suggest to the visitor to stop walking. The visitor should be near the exhibit where the narration will take place.


**Figure 28: Prototype of screen while user is walking**


**Figure 29: Prototype of screen when user is in front of a display case**

By choosing the option “Listen to this story” the visitor will be led to the narration mode of application. We want to design an interface that on the default option, all the necessary information will be given. Hence, if the area of interest is already visited, an indication should appear and the layout should adapt to each user’s state.

An important designing choice is how the user is supposed to exit the experience and be led to the review of her choices. To unlock the option of reviewing the experience, the user should have visited at least one zone and make at least one choice using the

tangible. Otherwise, there is no point of reviewing the choices. Hence, an option to finish the experience should appear on the right side of the action bar when visitor finishes her first narration experience.

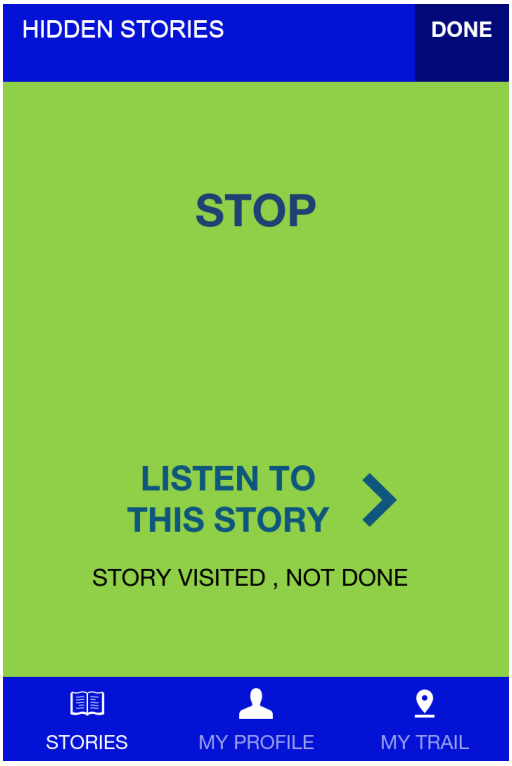



**Figure 30: Prototype of a screen after user exits the narration part**

Besides the default option “Stories”, the user should have access to her profile and her trail inside the museum. The options can be chosen by selecting the desired option or by swiping right.

On option “My Profile”, a list of stories and characters listened during the visit is displayed. This option provides a visitor with an accurate representation of her choices and gives her the option to like or dislike a story. The possibility to mark a story as favorite could serve as a tool of evaluation and as a proof that the users engaged with some character. Moreover, the favorite’s option can help us form a more personalized visit based on previous user’s choices. We decided to refer to stories by using the character’s name and the color that was connected to this character. This could embrace users connect emotions with characters without our contribution.

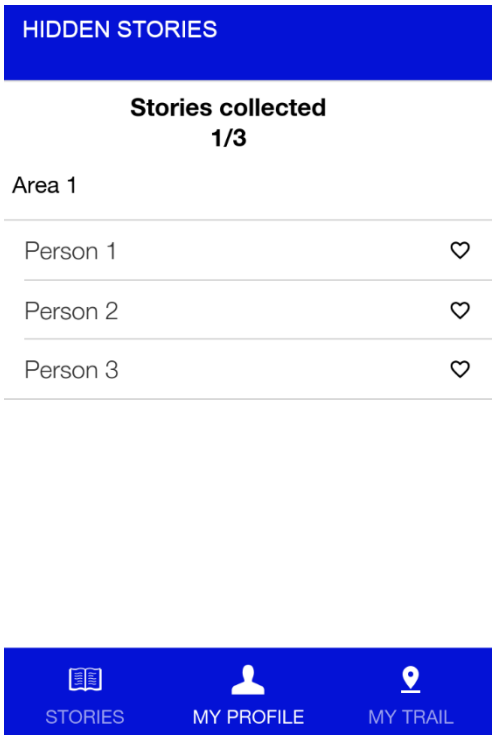



**Figure 31: Prototype of user's profile**

To enhance the user's wayfinding inside the museum, we suggest the use of an interactive map. A museum is a place full of exhibits for which the user does not have any previous knowledge. In case we do not want to reveal the number of interactive areas to visitors, we have to provide them with a support material.

An interactive map or a floor map of the museum where the areas of interest are marked with pin icons could support users' navigation. The distinction among visited and not visited areas should be given by the use of different colors, like green for visited and orange for not visited. As a supplemental functionality, by choosing a marked area, a photo of the display case can be shown to help visitor locate the specific exhibit. If the marked area chosen is already visited, the visitor could navigate through her choices related to the specific area.

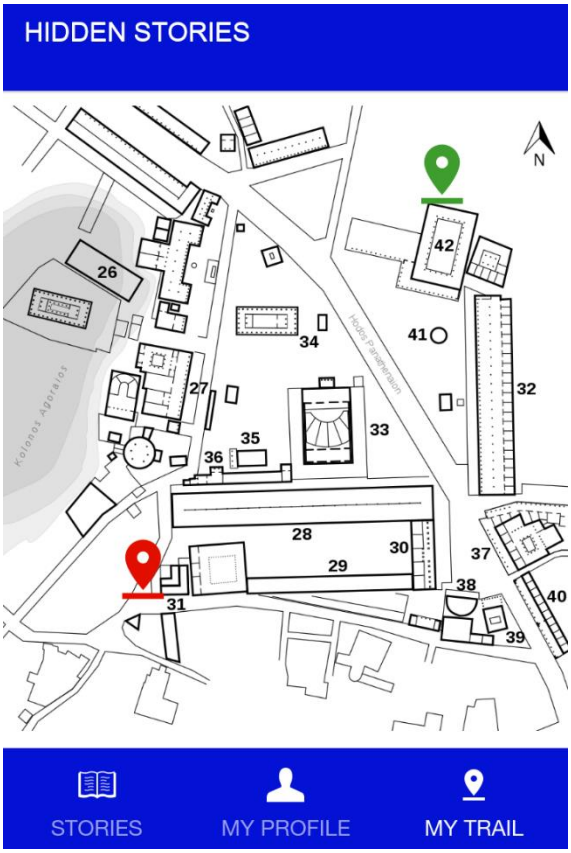



**Figure 32: Prototype of interactive map in "My Trail" option**

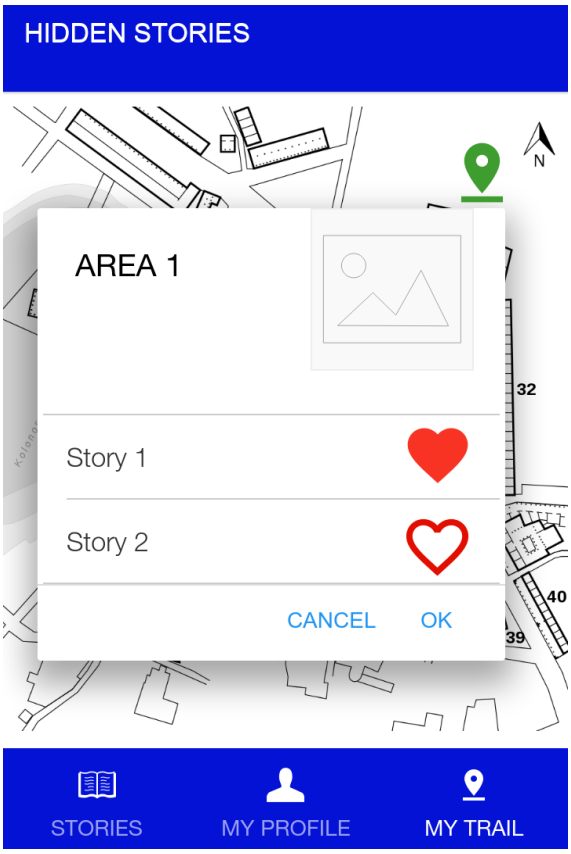



**Figure 33: Prototype of screen when user demands further information of an area**

The second part of the application takes place while user stands in front of the right exhibit and she has chosen to start the narration by pressing the button "Listen the story".

### Visitor's state: Standing

During this part, the visitor has now to interact with the tangible and choose an emotion to initialize the storytelling part of the experience. On this screen layout, two options are offered; the default Narration option and User Collection. In order to follow the concept of brief instructions as a mean of communication and maintain a feeling of intimacy, we choose to ask visitor a question about whose story desires to listen. In case the visitor is stacked, the information button on top should be available to provide help.

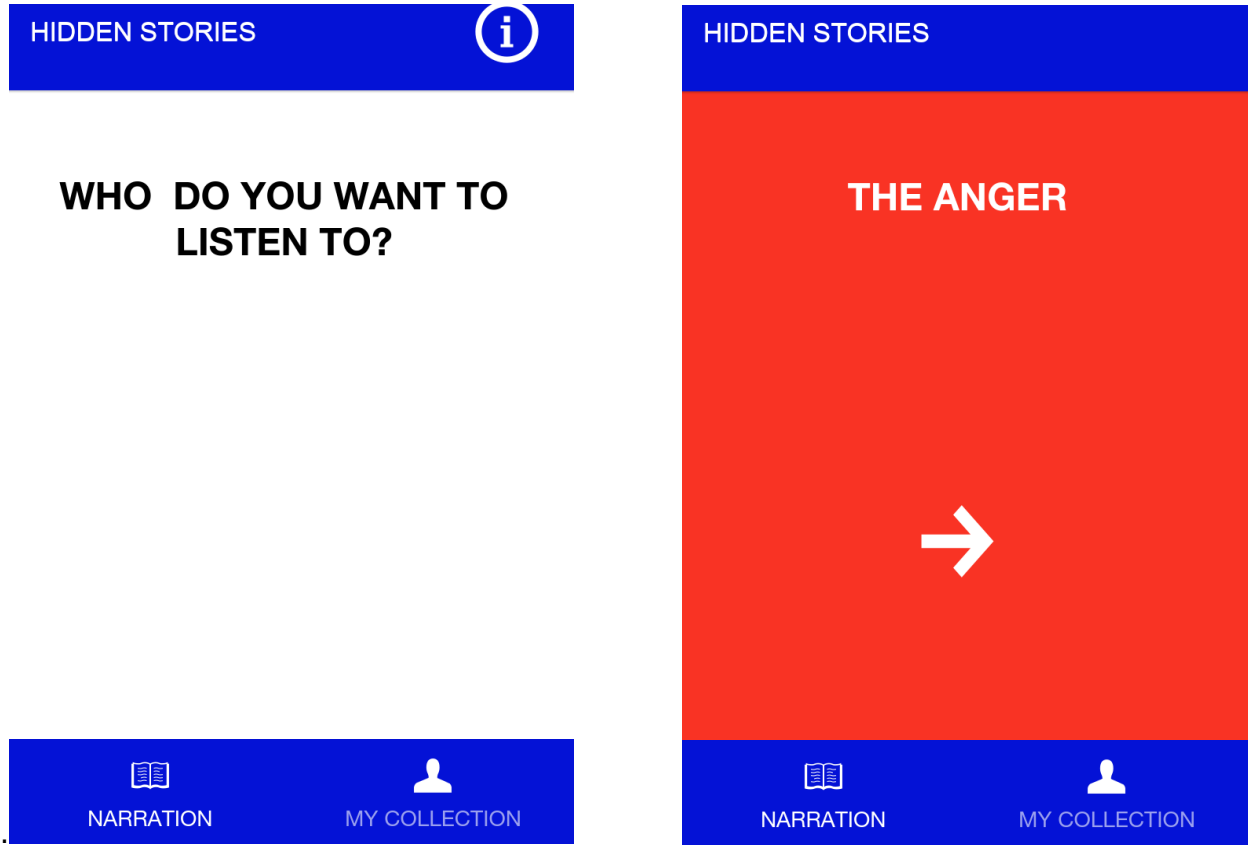



**Figure 34: Prototypes of screens during tangible interaction. User demands to listen emotion Anger**

While the user is interacting with the tangible and she is tapping the phone on tangible's sides, the screen is going to display the related emotion associated with the proper color according to the mapping discussed above. In case a connection fails, a message to try again will be displayed.

After a successful interaction with the tangible, the narration follows. The visitor can reveal the person behind the narration and continue to another character or exit the narration mode. To exit most android users use the back button. The back button of the device could serve as a back to the walking menu option, so we don't need to use extra icons and buttons for basic functions like this. In case this way of exit is not usable to users we can add a back arrow on the action bar.

Throughout the story's narration, audio and text will be shown. To give to the user the control of the narration we have to provide her with audio player buttons such as play, replay, and pause. At this point, we have to prevent the constant screen staring. The too long text will disengage the user immediately. A possible way to avoid long text display is to hide it and reveal it only when the user requests.


**Figure 35: Prototype of screens during storytelling and character revealed**

### Visitor's state: Leaving

If the visitor is willing to quit the experience, the Agora will offer her a personalized profile related to her emotion's choices. The review of the visitor's choices and the generation of a profile based on previous actions will give the idea of personalization to visitors. However, this is not a complete conclusion of the experience. As it was stated in chapter 2, visitors appreciate more a personalized souvenir. In this stage of our research, the mobile interface could provide an option of sharing the profile on social media. Similar to personalized quizzes on Facebook, the user can share the result of their visit to the Ancient Market museum online, like a statistical analysis of their choices based on emotions.


**Figure 36: Prototype of User's Profile generated by Agora to keep as a "souvenir"**

### 3.6.7 Findings

Following the prototypes' creation, we proceed to a series of formative evaluations and focus groups by researchers. These first evaluations helped us improve the design of the experience. Firstly, regarding the idea of interaction with the tangible the users did not face any problem since there was an introduction to the whole experience. The principal concept of the experience; walking and messages popping up to the screen were also commented positively as a way to avoid looking at the screen. Deriving by this comment, we choose to add a short vibration, to inform visitor to search further for a nearby zone of interest.

The most crucial problem detected appears to be the absence of a "hint" button. The experience is based on exploring museum space for zones of interest. Regarding the user's wayfinding, information concerning actions to perform is being given such as walk, stop. Except for an audio description of the display case, no other information is provided. Thus, we consider the current way of wayfinding as weak. The direct access to a "hint" button can help the user feel less insecure about what she is looking for, or if she is in front of the right display case. It is a user experience issue to provide the user with further information to prevent her from getting stuck.

As this evaluation revealed, the indication concerning the stop action should be given in a close range with the artifacts. A "search" step and a button "I am here" should be added before notifying the user to stop and unlock information of a specific display case. Finally, we observed that the user has to be explicitly informed when the use of tangible is required to proceed. A discreet sign when the tangible interaction is demanded is essential to clarify the interaction.

# 4. IMPLEMENTATION

## 4.1 Introduction

Technically speaking, the location-aware storytelling experience that we designed demands primarily a mobile application and secondary technologies which can handle the localization of user inside the museum and her appropriate interaction with the tangible. On the next chapters of this section, the technologies used for our implementation are described and a short general architecture of the main application's functions is given.

## 4.2 Used technology

From a technical point of view, the experience is separated into three main areas; the localization-tracking of user inside the museum, the tangible interaction and emotions' identification and the main storytelling application which, in background, handles the previous technologies and, in the foreground, is responsible for the narration of the story.

### 4.2.1 Location Beacons

For the indoor localization of user, we use a beacon technology. Basically, beacon's technology is going to implement the areas of interest that were described in the designing chapter. In our implementation we use the Location Beacons made by Estimote's company that are part of a bigger technological family, the Bluetooth beacons.

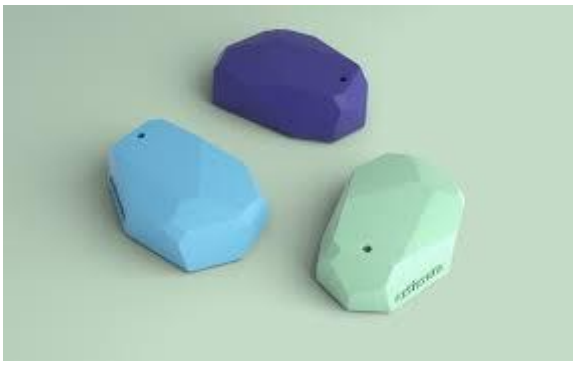


**Figure 37: Estimote Location Beacons**

To start with, we shall explain what beacon technology is in general. Bluetooth beacons are hardware transmitters - a class of Bluetooth low energy (LE) devices that broadcast their identifier to nearby portable electronic devices. The technology enables smartphones, tablets and other devices to perform actions when in close proximity to a beacon.

Bluetooth beacons use Bluetooth low energy proximity sensing to transmit a universally unique identifier picked up by a compatible app or operating system. The identifier and several bytes sent with it can be used to determine the device's physical location, track user's devices, or trigger a location-based action on the device such as a check-in on social media or a push notification.

Bluetooth beacons differs from some other location-based technologies as the beacon is only a 1-way transmitter to the receiving smartphone or receiving device, and necessitates a specific app installed on the device to interact with the beacons. This ensures that only the installed app (not the Bluetooth beacon transmitter) can track users, as they passively walk around the transmitters.

Beacons, depending from the company manufacturer, use different protocols for communication. The most important are: iBeacon introduced by Apple in 2003, AltBeacon an open source alternative to iBeacon created by Radius Networks, URIBeacon which

are different from iBeacons and AltBeacons because rather than broadcasting an identifier, they send a URL which can be understood immediately and Eddystone Google's standard for Bluetooth beacons. For our application purposes, we used another beacon technology produced by Estimote.

Estimote specializes in indoor location tracking and deploys three different types of beacons: Proximity, Indoor-Location and Mirror. Proximity beacons signals to trigger enter and exit events. Indoor Location beacons use signals to compute an (x, y) position of user inside an area. Finally, Mirror beacon are capable of interaction between screens, i.e. smartphone screen and TV screen. For each beacon type, Estimote provides developers with a related API. However, Location Beacons can work with Proximity API also.

On our application, we used Location Beacons with Proximity API. Whilst Indoor API seemed to better serve our goals, we faced a lot of limitations and bugs, as it is the most recent tool of Estimote, and for this stage of the research we preferred to use Location Beacons as Proximity.

By going deeper into Estimote Beacons technology, we have to mention that beacons are tiny, specialized computers. Each beacon has: a low-power ARM® CPU e.g., 32-bit, 64 MHz CPU in Proximity beacons, or a quad-core, 64-bit, 1.2 GHz CPU in Mirror, a flash memory to store apps and data e.g., 512 kB in Proximity beacons, 8 GB in Mirror, a RAM memory for the apps to use while running e.g, 64 kB in Proximity beacons, 1 GB in Mirror and of course a Bluetooth antenna and chip to communicate with other devices, and between the beacons themselves.

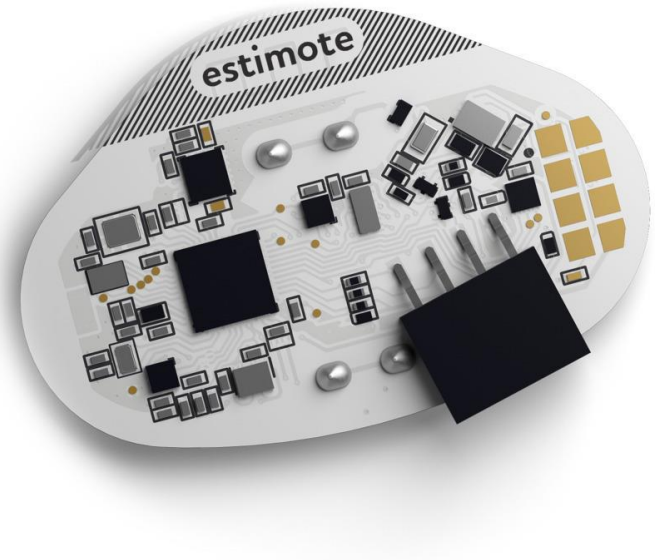



**Figure 38: The “inside” of an Estimote location beacon**

Estimote Beacons are generally optimized to run on battery power for months or years. Mirror video-beacon is the notable exception here, since it can draw the power from the TV/screen it’s connected to.

Unlike regular computers, which you interact with via keyboard, mouse, or touch-screen, Estimote Beacons are primarily interacted with via Bluetooth Low Energy (Bluetooth “LE”, or “BLE” in short). The Estimote SDK is responsible for all the Bluetooth-handling, leaving user to work with a higher-level API and application logic. Estimote SDKs are available for iOS, Android, and Android Things.

Estimote also provides developers with the Estimote cloud where beacons owned are listed. Developers can manage their beacons features easily from there and analyze beacons activity, for example visits per beacon area.

The communication between a BLE device and beacons is a very easy process either in the case that Estimote or another type of beacon is used. Beacons can carry data. The devices detect beacons, retrieve data of a certain beacon and handle them.

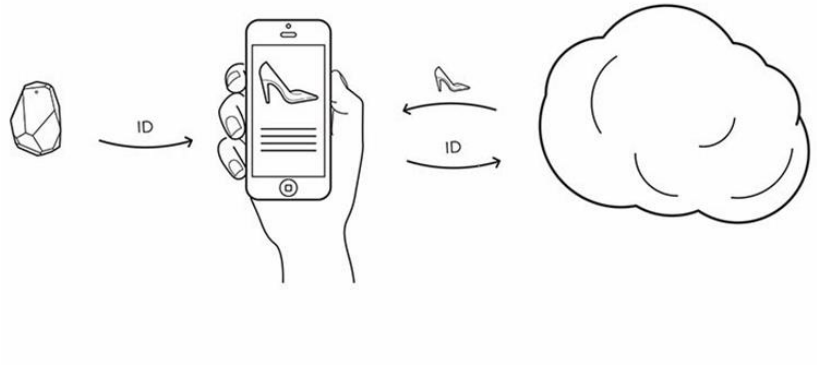



**Figure 39: Beacon, BLE and cloud communication**

By default, Estimote Beacons advertise every 200 ms = 5 times a second. However, smartphones don't continuously scan for BLE. For example, Android in "balanced" scanning mode has a 1,024 ms scanning window every 4,096 ms, so there's about 3 seconds of downtime between scans. (In the "low latency" scanning mode, it's a 4096 ms window every 4,096 ms, so that's actually a continuous scan.)

When the app is in the foreground, the OS and/or Estimote SDKs will generally try to use more aggressive scanning settings, to provide the user with the best and most responsive experience. The battery drain is still relatively small.

Therefore, beacon technology is simple, easy to set up and use, without many technical demands, but the detection, as it is a sensor technology, has always its flaws and sometimes appears unstable.

To add beacon detection in an android application, as it was stated before, Estimote offers a number of libraries. The application has to obtain app credentials from Estimote cloud (https://cloud.estimote.com/) in order to access the libraries. After a successful connection, a Proximity observer should be set up and then the Proximity Zones should be defined. The proximity observer handles "enter" and "exit" actions on the defined proximity zones. A zone is the area around each beacon and its range is declared by the developers during zone definition. The default range of a beacon proximity zone is 5 meters. For our implementation, we used a custom range of 1.5 meter. The "enter" and "exit" actions of proximity zones can provoke specific actions determined programmatically by the developer.

### 4.2.2 NFC

NFC is the second technology that we used. NFC is hidden from the user, embedded inside the tangible. The purpose of this technology was the emotions identification by the application when a user demands a specific chapter to be displayed.

Near-field communication (NFC) is a set of communication protocols that enable two electronic devices, one of which is usually a portable device such as a smartphone, to

establish communication by bringing them within 4 cm (1.6 in) of each other. [20] NFC can be found in different forms, for example tags, and rings.


**Figure 40: A NFC tag**

NFC works on the principle of sending information over radio waves. Near Field Communication is another standard for wireless data transitions. This means that devices must adhere to certain specifications in order to communicate with each other properly. The technology used in NFC is based on older RFID (Radio-frequency identification) ideas, which used electromagnetic induction in order to transmit information.

This marks the one major difference between NFC and Bluetooth/WiFi. The former can be used to induce electric currents within passive components as well as just send data. This means that passive devices don't require their own power supply. They can instead be powered by the electromagnetic field produced by an active NFC component when it comes into range.

The transmission frequency for data across NFC is 13.56 megahertz. The data send can be at 106, 212, or 424 kilobits per second. It is quick enough for a range of data transfers — from text details to swapping pictures and music.

To determine what sort of information will be exchanged between devices, the NFC standard currently has three distinct modes of operation. Perhaps the most common use in smartphones is the peer-to-peer mode. This allows two NFC-enabled devices to exchange various pieces of information between each other. In this mode both devices switch between active when sending data and passive when receiving.

Read/write mode, on the other hand, is a one-way data transmission. The active device, possibly your smartphone, links up with another device in order to read information from it. NFC advert tags use this mode.

The final mode of operation is card emulation. The NFC device can function as a smart or contactless credit card and make payments or tap into public transport systems.

The one-way transmission, read-write, of NFC is a very common and useful technology for cultural heritage. It offers a way of identifying artefacts and it is easy to be used by people. The most important factor is the shape and size of NFC tags which are easy to adjust to tangibles without adding any supplement weight. The only withdrawal is that not all smartphones are compatible with NFC technologies. As a result, if a cultural institution offers a "Bring Your Own Device" initiative, they have to avoid this type of technology and instead use QR codes.

For the application that we developed, we focused only on NFC reading action. Since NFC primarily activates mobile activities / launches mobile applications, we have to promote application over system when a NFC is detected, i.e. the application will handle the message and not the main mobile system. To do so, the right permissions (android.permission.NFC) have to be declared on android manifest file.

NFCs data is written in a standardized format called NDEF (NFC Data Exchange Format). Android has inbuilt support to create and write NDEF messages. In our implementation, we used the MIME type text/plain.

As we mentioned before, we embedded the NFC tags on the back of tangible's sides. The tags had a size of 4x4 cm and a range of 2 cm transmission consequently tangible's sides were isosceles triangles of 8 cm edges.

### 4.2.3 Android Operating System

Finally, the main interface was an application developed for Android smartphones. Android is a mobile operating system developed by Google, based on a modified version of the Linux kernel and other open source software and designed primarily for touchscreen mobile devices such as smartphones and tablets. In addition, Google has further developed Android TV for televisions, Android Auto for cars, and Wear OS for wrist watches, each with a specialized user interface. Variants of Android are also used on game consoles, digital cameras, PCs and other electronics. Applications ("apps"), which extend the functionality of devices, are written using Android software development kit (SDK) and, often, the Java programming language. Java may be combined with C/C++, together with a choice of non-default runtimes that allow better C++ support. The Go programming language is also supported, although with a limited set of application programming interfaces (API). In May 2017, Google announced support for Android app development in the Kotlin programming language.


**Figure 41: Android Logo**

### 4.2.4 Android Studio & Android software development

In order to develop apps that take advantage of the Android operating system and UI, the Android software development kit (SDK) has to be used. The SDK includes a comprehensive set of development tools including a debugger, software libraries of prewritten code, a device emulator, documentation, sample code, and tutorials.


**Figure 42: Android Studio 3.0 logo**

To develop apps using the SDK, the Java programming language is used for developing the app and Extensible Markup Language (XML) files for describing data resources. By writing the code in Java and creating a single app binary, the app produced can run on both phone and tablet form factors. UI has to be declared in lightweight sets of XML resources, one set for parts of the UI that are common to all form factors, and other sets for features specific to phones or tablets. At runtime, Android applies the correct resource sets based on its screen size, density, locale, and so on.

To help the development of applications efficiently, Google offers a full Java Integrated Development Environment (IDE) called Android Studio, with advanced features for developing, debugging, and packaging Android apps. Using Android Studio, development can be done on any available Android device, or there is the option to create virtual devices that emulate any hardware configuration.

Android provides a rich development architecture. There is no need to know much about the components of this architecture in order to develop an application, but it is always useful to know what is available in the system for the developing app to use. The following diagram shows the major components of the Android stack — the operating system and development architecture.

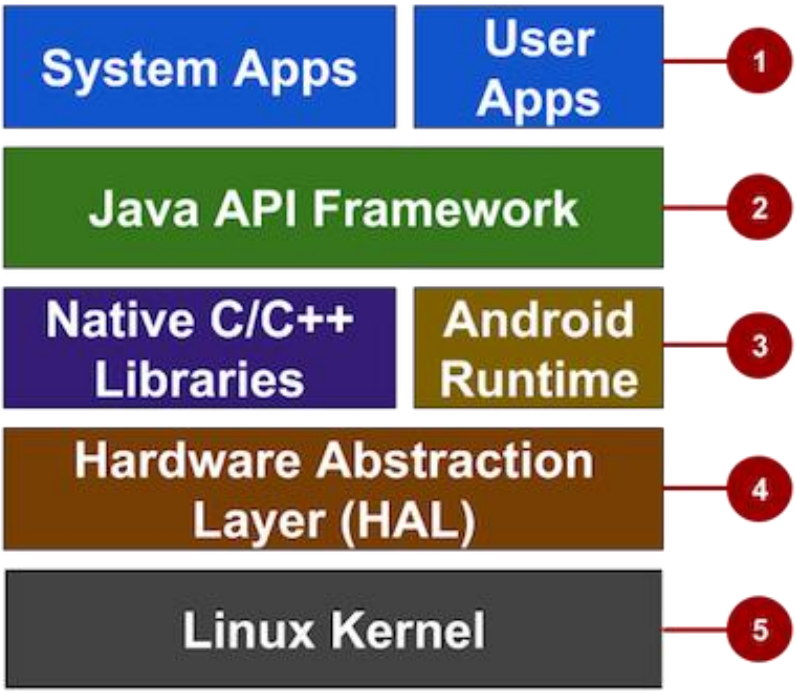



**Figure 43: Android OS Hierarchy**

In the figure above:

1) Apps: The apps live at this level, along with core system apps for email, SMS messaging, calendars, Internet browsing, or contacts.

2) Java API Framework: All features of Android are available to developers through application programming interfaces (APIs) written in the Java language. The following APIs are useful for creating apps:

- View System used to build an app's UI, including lists, buttons, and menus.
- Resource Manager used to access to non-code resources such as localized strings, graphics, and layout files.
- Notification Manager used to display custom alerts in the status bar.
- Activity Manager that manages the lifecycle of apps.
- Content Providers that enable apps to access data from other apps.
- All framework APIs that Android system apps use.

3) Libraries and Android Runtime: Each app runs in its own process and with its own instance of the Android Runtime, which enables multiple virtual machines on low-memory devices. Android also includes a set of core runtime libraries that provide most of the functionality of the Java programming language, including some Java 8 language features that the Java API framework uses. Many core Android system components and services are built from native code that requires native libraries written in C and C++. These native libraries are available to apps through the Java API framework.

4) Hardware Abstraction Layer (HAL): This layer provides standard interfaces that expose device hardware capabilities to the higher-level Java API framework. The HAL consists of multiple library modules, each of which implements an interface for a specific type of hardware component, such as the camera or Bluetooth module.

5) Linux Kernel: The foundation of the Android platform is the Linux kernel. The above layers rely on the Linux kernel for underlying functionalities such as threading and low-level memory management. Using a Linux kernel enables Android to take advantage of key security features and allows device manufacturers to develop hardware drivers for a well-known kernel.

An Android app project begins with an idea and a definition of the requirements necessary to realize that idea. As the project progresses, it goes through design, development, and testing.

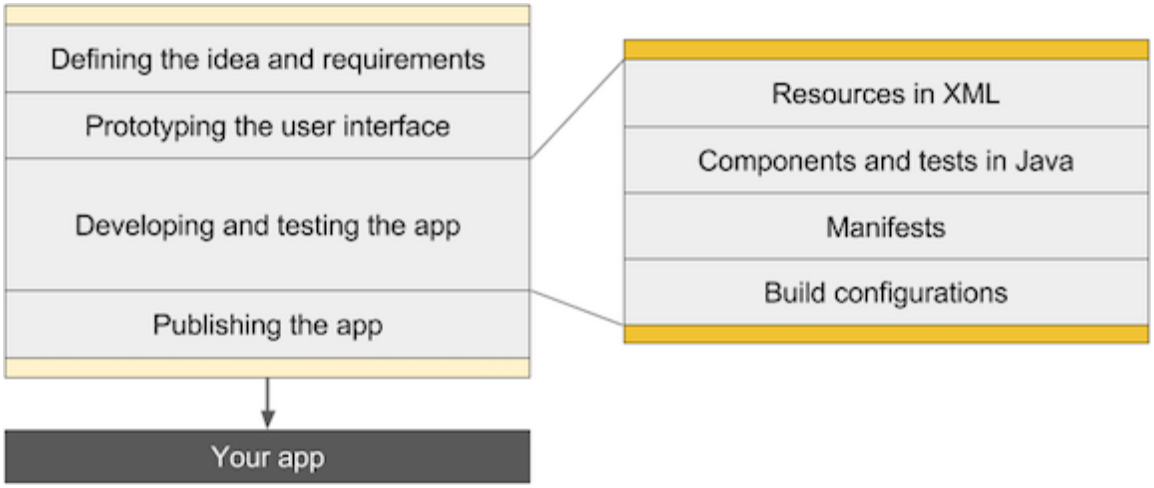



**Figure 44: Process of an android application design**

The above diagram is a high-level picture of the development process, with the following steps:

- **Defining the idea and its requirements:** Most apps start with an idea of what it should do, bolstered by market and user research. During this stage the app's requirements are defined.
- **Prototyping the user interface:** Use drawings, mock ups and prototypes to show what the user interface would look like, and how it would work.
- **Developing and testing the app:** An app consists of one or more activities. For each activity you can use Android Studio to do the following, in no particular order:
    - **Create the layout:** Place UI elements on the screen in a layout, and assign string resources and menu items, using the Extensible Markup Language (XML).
    - **Write the Java code:** Create source code for components and tests, and use testing and debugging tools.
    - **Register the activity:** Declare the activity in the manifest file.
    - **Define the build:** Use the default build configuration or create custom builds for different versions of your app.
- **Publishing the app:** Assemble the final APK (package file) and distribute it through channels such as the Google Play.

On the next part of this section, we are going to analyze two important parts of an android application; the Activities and the Fragments. Basically these two organize the application functionality and play a big role on forming user experience.

Firstly, the activity of an android application represents a single screen in this app with an interface the user can interact with. For example, an email app might have one activity that shows a list of new emails, another activity to compose an email, and another activity for reading individual messages. An application is a collection of activities that are either created by the developer, or that are reused from other apps.

Although the activities in an app work together to form a cohesive user experience each one is independent of the others. This enables the app to start activities in other apps, and other apps can start these activities. Each time a new activity starts, the previous activity is stopped, but the system preserves the activity in a stack (the "back stack").

When the user is done with the current activity and presses the Back button, it is popped from the stack (and destroyed) and the previous activity resumes.

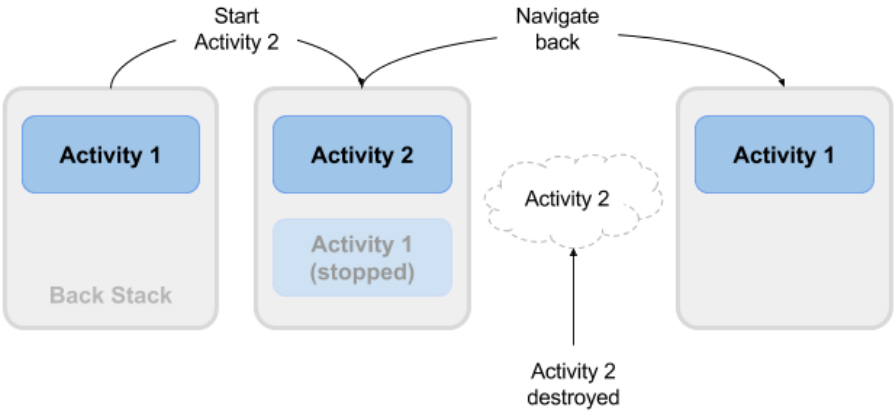



**Figure 45: Back button navigation and impact to activities**

When an activity is stopped because a new activity starts, the first activity is notified of that change with the activity's lifecycle callback methods. The Activity lifecycle is the set of states an activity can be in, from when it is first created, to each time it is stopped or resumed, to when the system destroys it.

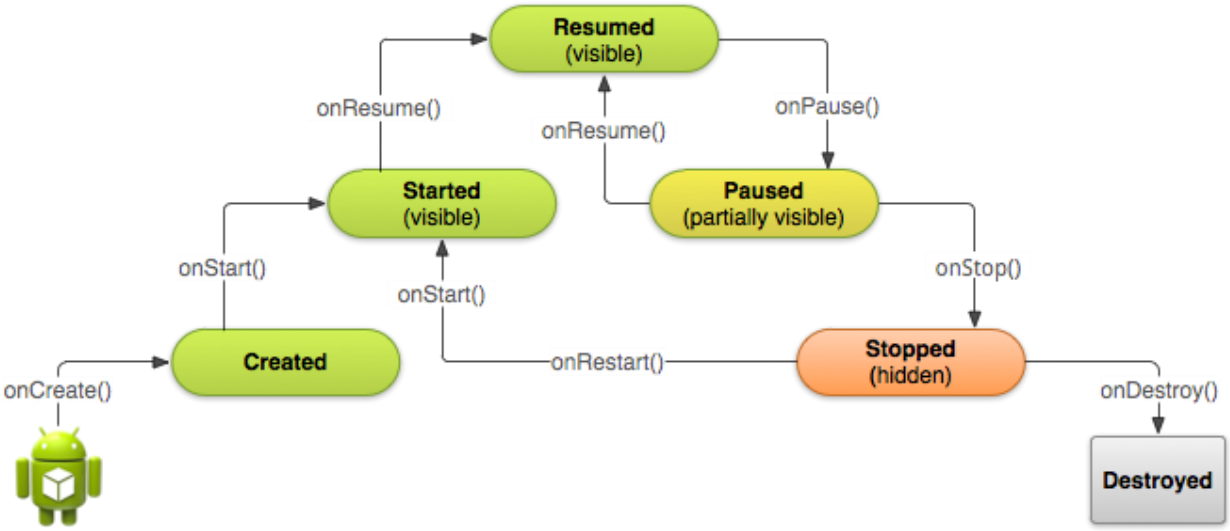



**Figure 46: Basic Lifecycle of an Activity**

The lifecycle of an activity is an essential knowledge to every android developer because it relates to how the total application finally will behave.

Another important parameter of activities is their communication, how data from one screen/activity can be reused by the next one. This happens by Intents, which are messaging objects that can be used to request an action from another app component.

There are two types of intents:

- **Explicit intents** specify which application will satisfy the intent, by supplying either the target app's package name or a fully-qualified component class name. For example, when we start a new activity within an app in response to a user action, or start a service to download a file in the background.

- **Implicit intents** do not name a specific component, but instead declare a general action to perform, which allows a component from another app to handle it. For example, if we want to show the user a location on a map, we can use an implicit intent to request that another capable app show a specified location on a map.

For this application we mainly focus on implicit intents. When an implicit intent is used, the Android system finds the appropriate component to start by comparing the contents of the intent to the intent filters declared in the manifest file of other apps on the device. If the intent matches an intent filter, the system starts that component and delivers it the Intent object. If multiple intent filters are compatible, the system displays a dialog so the user can pick which app to use.

An intent filter is an expression in an app's manifest file that specifies the type of intents that the component would like to receive. For instance, by declaring an intent filter for an activity, it enables other apps to directly start the current activity with a certain kind of intent. Likewise, if no intent filter is declared for an activity, then it can be started only with an explicit intent.

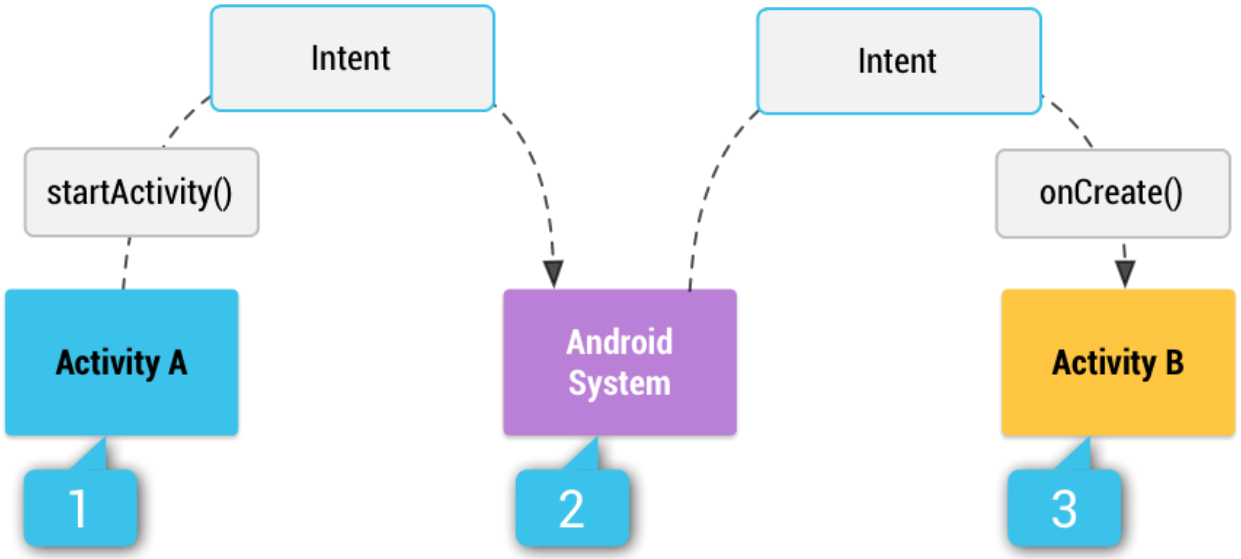



**Figure 47: How an implicit intent is delivered through the system to start another activity: (1) Activity A creates an Intent with an action description and passes it to startActivity(). (2)The Android System searches all apps for an intent filter that matches the intent. When a match is found, (3) the system starts the matching activity (Activity B) by invoking its onCreate() method and passing it the Intent.**

Focusing now on Fragments. A Fragment represents a behavior or a portion of user interface in a FragmentActivity. Multiple fragments can be combined in a single activity to build a multi-pane UI and a fragment can be reused in multiple activities. A fragment is like a modular section of an activity, which has its own lifecycle, receives its own input events, and which can be added or removed while the activity is running (sort of like a "sub activity" that you can reuse in different activities).

A fragment must always be hosted in an activity and the fragment's lifecycle is directly affected by the host activity's lifecycle. For example, when the activity is paused, so are all fragments in it, and when the activity is destroyed, so are all fragments. However, while an activity is running (it is in the resumed lifecycle state), each fragment independently can be manipulated directly, such as add or remove them. When such a fragment transaction is performed, it can also be added to a back stack that's managed by the activity—each back stack entry in the activity is a record of the fragment transaction that

occurred. The back stack allows the user to reverse a fragment transaction (navigate backwards), by pressing the Back button.

Android introduced fragments in Android 3.0 (API level 11), primarily to support more dynamic and flexible UI designs on large screens, such as tablets. Each fragment should be designed as a modular and reusable activity component. That is, because each fragment defines its own layout and its own behavior with its own lifecycle callbacks, one fragment can be included in multiple activities. This is especially important because a modular fragment allows us to change the fragment combinations for different screen sizes. When designing an application to support both tablets and handsets, we can reuse the fragments in different layout configurations to optimize the user experience based on the available screen space. For example, on a handset, it might be necessary to separate fragments to provide a single-pane UI when more than one cannot fit within the same activity.

Furthermore, the Fragment class is based on a code that looks a lot like an Activity. It contains callback methods similar to an activity, such as onCreate(), onStart(), onPause(), and onStop(). In fact, if you're converting an existing Android application to use fragments, you might simply move code from your activity's callback methods into the respective callback methods of your fragment.

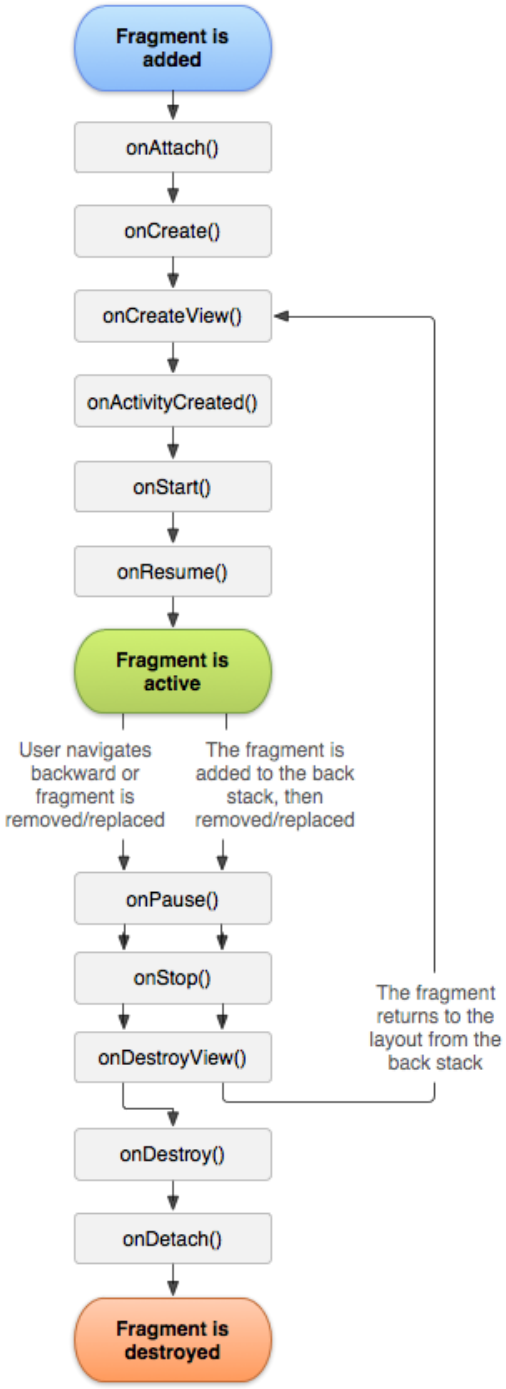



**Figure 48: Fragment Lifecycle**

There are also a few subclasses that can be used, instead of the base Fragment class: Dialog Fragment, List Fragment, and Preference Fragment Compat.

Often we need one Fragment to communicate with another, for example to change the content based on a user event. All Fragment-to-Fragment communication is done either through a shared ViewModel or through the associated Activity. Two Fragments should never communicate directly.

The recommended way to communicate between fragments is to create a shared ViewModel object. Both fragments can access the ViewModel through their containing Activity. The Fragments can update data within the ViewModel and if the data is exposed using LiveData the new state will be pushed to the other fragment as long as it is observing the LiveData from the ViewModel.

### 4.2.5 JSON

JSON file was used to store external data of our application. The file that we used for our implementation is found on ANNEX. In particular, JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language, Standard ECMA-262 3rd Edition - December 1999. JSON is a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family of languages, including C, C++, C#, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal data-interchange language.

JSON is built on two structures:

- A collection of name/value pairs. In various languages, this is realized as an object, record, structure, dictionary, hash table, keyed list, or associative array.
- An ordered list of values. In most languages, this is realized as an array, vector, list, or sequence.

These are universal data structures. Virtually all modern programming languages support them in one form or another. It makes sense that a data format that is interchangeable with programming languages also be based on these structures. In JSON, they take on the forms of an object, an array, a value, a number and a string.

An **object** is an unordered set of name/value pairs. An object begins with { (left brace) and ends with } (right brace). Each name is followed by: (colon) and the name/value pairs are separated by, (comma).

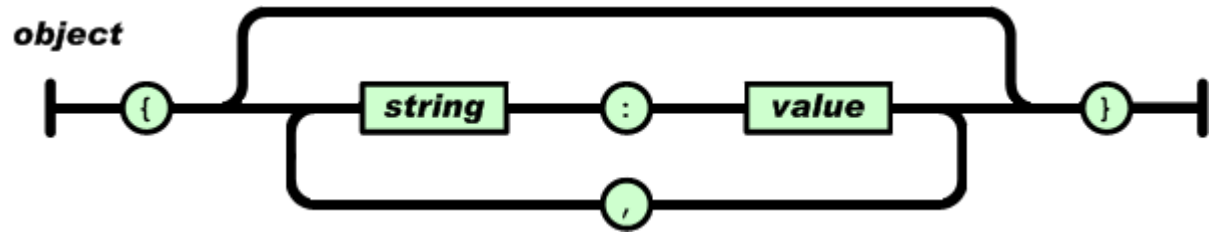



**Figure 49: Graphic representation of Object structure in JSON files**

An **array** is an ordered collection of values. An array begins with [ (left bracket) and ends with ] (right bracket). Values are separated by, (comma).

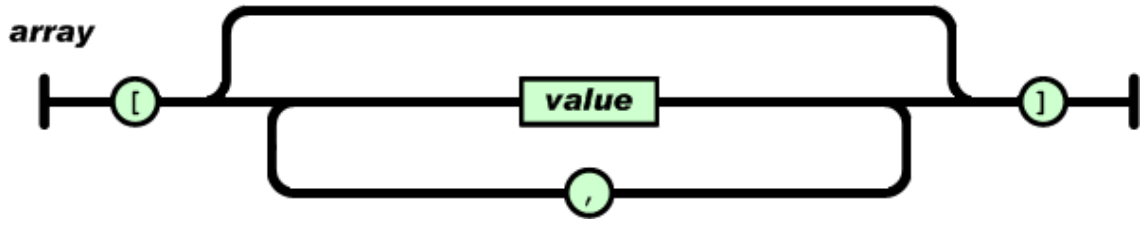



**Figure 50: Graphic representation of Array structure in JSON files**

A **value** can be a string in double quotes, or a number, or true or false or null, or an object or an array. These structures can be nested.

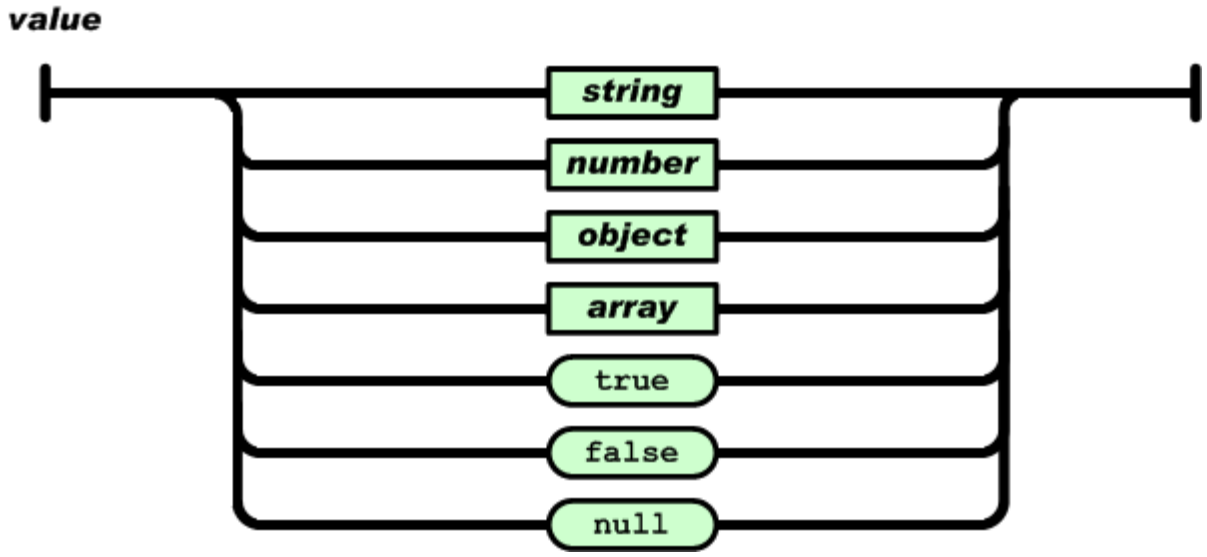



**Figure 51: Graphic representation of value structure in JSON files**

A **string** is a sequence of zero or more Unicode characters, wrapped in double quotes, using backslash escapes. A character is represented as a single character string. A string is very much like a C or Java string.

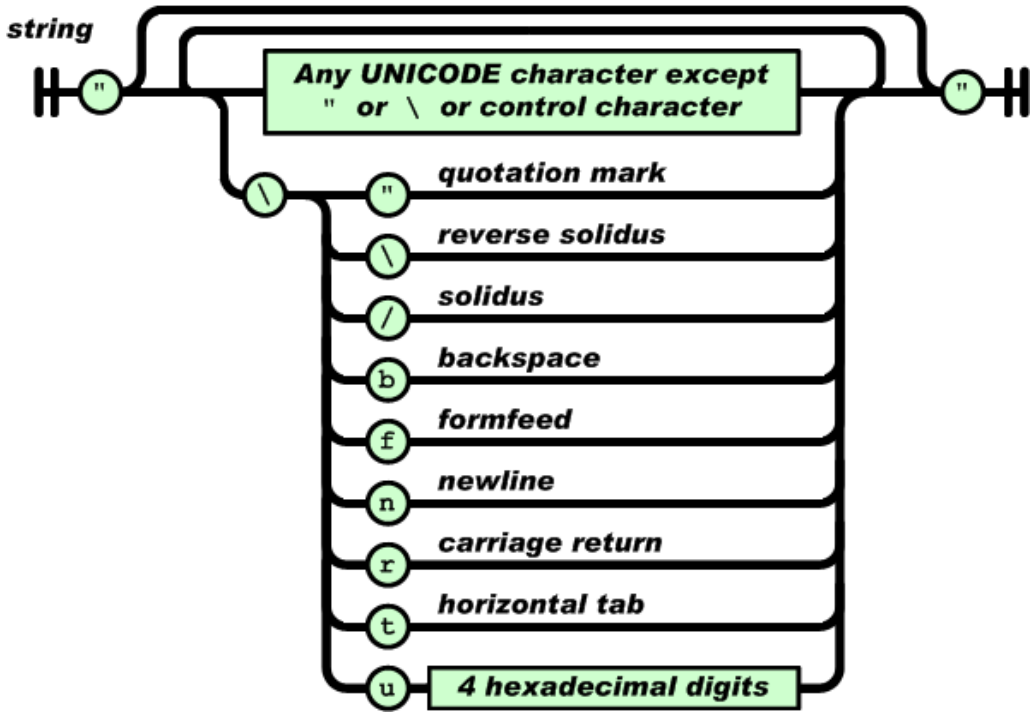



**Figure 52: Graphic representation of String structure in JSON files**

A **number** is very much like a C or Java number, except that the octal and hexadecimal formats are not used.

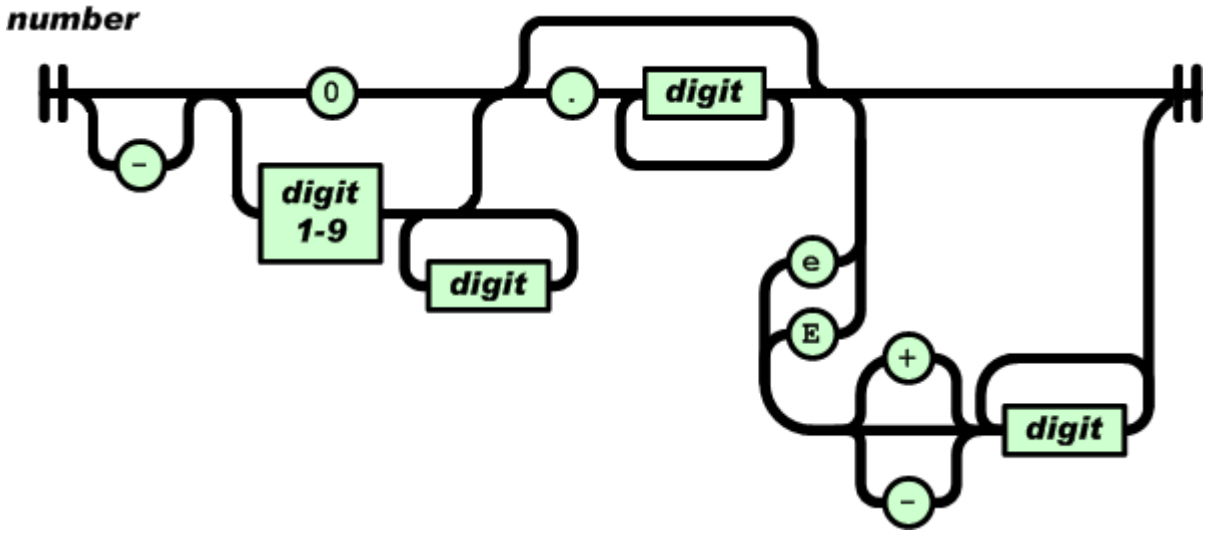



**Figure 53: Graphic representation of number structure in JSON files**

Whitespace can be inserted between any pair of tokens, except from a few encoding details that completely describe the language.

## 4.3 Structure of the application

In this chapter, the structure of the developed application is presented. The functionality of our application is organized on activities and fragments. Each activity or fragment carries a role to the total application. Hence, we are going to present the general architecture that implements the scenario of the previous chapter and then make a small briefing on each activity/fragment features.

A graphic representation of our android application follows. The classes below consist the screen layout of the app. Other classes were created supplementary for some application features like ViewPagerAdapter or BottomNavigationBar.

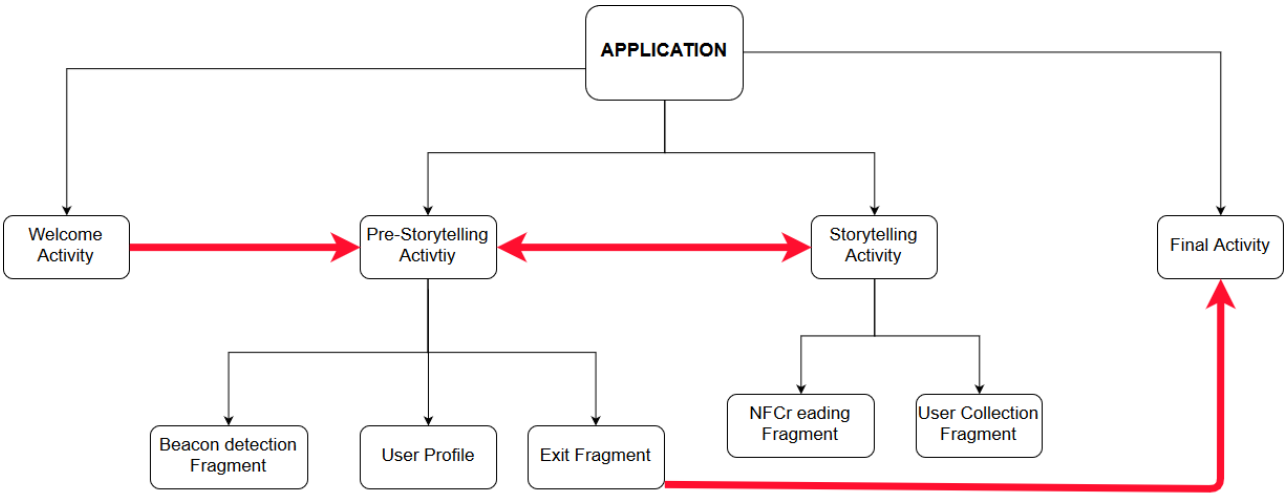



**Figure 54: Application structure, red arrows implicate the flow of application activities**

### Welcome Activity

Welcome Activity's layouts are the first screens that the user. This activity is responsible for the proper introduction of the user to the application and the storytelling experience. On this activity we handle parallel actions. To manage that, we used the Asynchronous Task (AsyncTask) of Android API 3 was used. AsyncTask enables proper and easy use of the UI thread. This class allows to perform background operations and to publish results on the UI thread without having to manipulate threads and/or handlers.

On foreground, the activity trains the user on how to use the tangible. In this part, we chose a simple UI that combines audio and text. While the application integrates the user to the storytelling experience, the activity, using the Asynchronous Task of Android, downloads and stores locally the data from the JSON file.

The JSON file is uploaded to http://myjson.com. This website creates a unique URI, using which our application can directly find and connect to the JSON file that we want.

All this procedure is finalized once the background letting user becomes familiarized with the application and the tangible. Only if an error occurs, the visitor is informed. After the trial, a Start button is revealed on screen and the user is ready to start walking through the space. By this button, Pre-Storytelling Activity starts.

**Pre-Storytelling Activity**

This activity is responsible for the part that the visitor is walking around inside the space of the museum and handles the exit of experience. On the bottom part of this activity layout, there is a navigation menu that consists of the main screen option, the “My Profile” option and “Exit”. The three separate fragments; User’s Profile, Beacon Detection and Exit Fragments of the above figure implement these two functions. The activity’s role is to coordinate them.

Beacon detection Fragment, as the title indicates, is responsible for the detection of beacons. Each beacon represents a point of interest/artefact inside the museum and sets a proximity zone around this spot. To create this fragment we set up a proximity observer from Estimote Proximity API with the zone’s range at 1.5/1 meter. Furthermore, we made use of another Estimote library, the Requirement Wizard. The functions of this library check and ask for mobile’s permissions, as Estimote Beacons require the Bluetooth option on and permissions for location access.

On this screen, two different views are displayed. When the user is outside of a proximity zone, the screen displays a text which encourages user to move. If the visitor enters a proximity zone, meaning that she is near the artefact’s area, an audio that calls her to come closer starts and a button to proceed to the story narration is shown.

The Fragment User’s Profile, presents the list of stories that user heard through the total experience. Stories are connected to tangible sides, therefore the list contents appear on different colors and their title is the main character of each story. Also, on that list, the visitor has the option to mark a story as favorite. By the current stage of our application, favorites do not have any serious contribution to the final experience, i.e. an option is to repeat these stories. However the implementation of such an option is included. We are going to wait until the evaluation part to understand if this option is useful or not for the future users.

Exit Fragment leads user to the Final Activity and handles the data transmission between Main Pre-Storytelling activity and final.

Pre-Storytelling and Storytelling activity have a two-way communication. Pre-Storytelling activity starts the Storytelling activity, while Storytelling Activity returns its results, meaning the chapters/stories heard on this stage. That’s why the yellow arrow of the diagram is bidirectional.

**Storytelling Activity**

Storytelling Activity represents the set of screens that the user sees while she stands in front of an artefact. On the screens of this activity, there is also a bottom navigation menu which has three options; Narration, My Collection and About. These three options are again implemented by Fragments, the Narration Fragment, and the User’s Collection

Fragment. The option “About” is the informational part and is also implemented by the Narration Fragment but separated due to design choices.

Practically, User’s Collection Fragment has similar functionality with the User’s Profile Fragment, except from the fact that on this screen this story’s chapters are presented. We choose to implement this function in order to help user keep track of hers storytelling experience.

Narration Fragment is responsible for the NFC reading from the tangible and the story display. When Storytelling Activity starts, the user is found on the screen of the narration fragment and has to touch her mobile to the tangible side, read the NFC behind this side, in order to proceed to the related story narration.

During the narration, text and audio are displayed. Moreover, player’s buttons to control audio file are placed under the text. To continue, by pressing “Who was talking” button, users can reveal which historic character was behind the narration. The exit is succeeded by the android back button for Android users or a back button on action bar of others.

At NFC reading phase, on the action bar of the screen there is an icon button of information. If the user does not remember how to proceed to the story narration, by this button pressed, a Dialog Fragment will pop up and a related animation and text will be displayed.

**Final Activity**

Either the visitor heard all of the stories or was bored; she can exit and get a personalized result by pressing the tick button which is placed on the right of Pre-Storytelling Activity the action bar.

Hence, the Final Activity is the calculation of a result based on user’s emotions choices during the main experience and the display of the final result. From her choices, the negative and positive emotions of the tangible, this activity decides if the visitor is a pessimist or an optimist person. Then, a relevant image and text are going to appear on screen.

An operation of sharing on social media was also implemented in this step. For this operation, the current activity requests the creation of an external intent that will send a photo to the user's chosen social media.

# 5. EVALUATION

## 5.1 Introduction

In this chapter, we refer to the evaluation part of our project's experience. The evaluation is a crucial and obvious requirement for the development of notable digital interactive experiences. Firstly, we are going to review the evaluation methodology and the procedure that we follow. In the last part of this chapter, the findings of the evaluation are presented.

## 5.2 Evaluation Methodology

During the designing and the implementation of an experience, it is very easy to proceed to possible admissions concerning user's behavior. It is well-stated that even if designers may have a big experience regarding a specific domain, they can never get in the user's place and act like one. Hence, the evaluation with real users is an essential part of every project.

As it was mentioned on chapter 3, throughout this project we ran some short formative evaluations and tests with other researchers and a multidisciplinary audience. Beyond this method, it is important to test our work with more un-biased users. The results of this evaluation will serve as food for thought and future work.

The measurement of user experience is a complicated procedure as long as the total experience consists to a location-aware experience combined with tangible interaction. At the same time, the storytelling experience is based on emotionally-led interactive stories. Therefore this study's evaluation demands a combination of evaluation methods.

As this project's experiment is probing user response, it is important to capture feedback while the experience is going on. Hence, as a first evaluation method we are going to adopt the think aloud protocol. The think aloud protocol is used to capture spontaneous reactions or behaviors that might not seem significant to users and will not be remembered after the event. The think aloud protocol is a method by which the researcher walks beside the player, usually with an audio recorder, and encourages them to say what they are thinking. [21]

Another important and necessary evaluation method for our experiment is the observation. Observation technique is to shadow a visitor, by following them at a discrete distance and recording what they do either in video form or with notes. [21] This technique was not selected only for examining user's interaction with the application during the evaluation, but also as a method to evaluate emotions. Facial, body and vocal expressions (e.g. smile, lean back, sigh) are taken into account considering visitors' emotions. [22]

Finally, regarding the reflection after the event we choose to run brief interviews to better understand the aspects of visitor's experience. The interview method that we chose is the semi-structured. Semi-structured interviews serve better our initial goals and in the same time their flexibility makes them well suited to answering a "why" question.[25] Questions are loosely structured to elicit views on how in control users felt; to reflect on how being in the actual place affected the experience; and to discuss any social interaction. All interviews will be transcribed and then analyzed to identify common themes, issues and feelings.

The empirical approach is to construct experiments that are controlled, measurable and repeatable. The methods that are used within an experiment are published so that other scientists might be able to recreate the experiment to verify the results or to build on the process. As a discipline research experiments that are conducted in the wild should

record significant aspects of the environment so that other researchers may replicate or build on the studies. [23] Hence, during the total experience and the interview, in case users accept this term, they will be record, for further/future examination.

## 5.3 Procedure

Since in the current phase the evaluation inside the actual museum of Ancient Market was not possible, we created a simulation of a part of the museum. We used one of the university's corridors to depict museum space. Printed posters replaced museum's display cases. The designed experience focus on two display cases, nonetheless we used 4 posters to fill the space and create the idea of museum space. Moreover, we did not want to make obvious to our visitors where areas of interest are located and incline them towards where an action may be triggered.

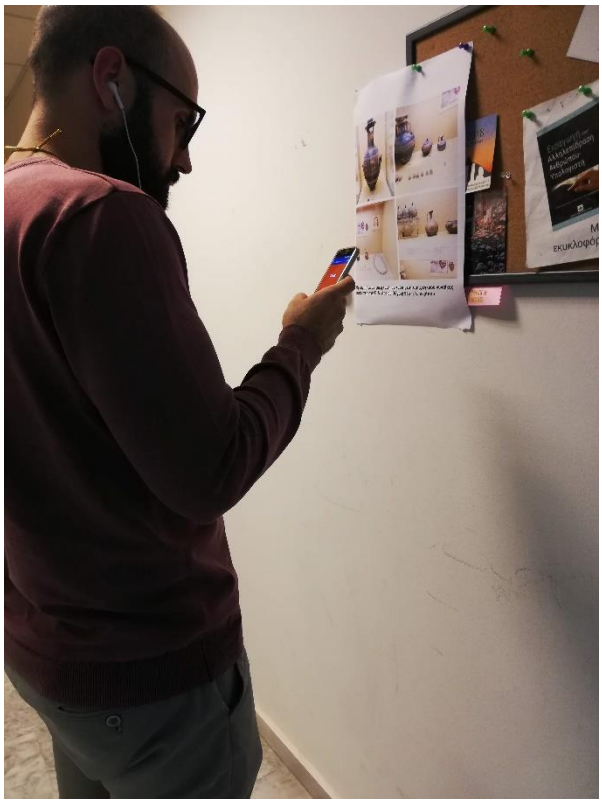


**Figure 55: User in front of an exhibit listening to the narration**

The beacons have a range of 1 meter. However due to technical reasons the range is not fixed and reliable. Hence we placed the beacons 3-4m away. Indeed, in the actual museum the display cases of our experience are 40 steps away.

The evaluation was done by 12 users, the majority of whom had a technical background. Hence, they were familiarized with project's technologies.

The experience can last from two minutes to 20 minutes, since each narration lasts 1 minute. The final experience consists of 2 stories, which have 8 chapters each. The seven chapters are connected with the emotions of tangible and the one is related to the informational part of the artifacts.

During the evaluation, the method followed was that of observation and the think aloud protocol. After the end of the experience, a semi-structure interview followed. Before the beginning of the museum experience the users were introduced to the experience context and informed about the aim of the project. The place was explained and the connections between the real museum and our simulation were clarifying. In order to help the users understand the procedure and prevent possible technical issues because of censors, we

informed them about the number of areas of interest and about the length of museum area. Since at the start of the mobile application, both an introduction and a trial existed, the experience was considered controllable and clear. Therefore no further instruction has been given. Additionally, the role of the visitor's shadow was made clear to eliminate questions and interventions. We asked users to perform as there was no one near them considering their possible feeling of obligation to like the application and try all features.

The goal of the observations was to firstly understand how easy was for the visitors to adapt to the experience. Moreover, we would like to observe the usability of the total experience. In this state, immersion and engagement are hard to succeed.

### 5.4 Findings

During the procedure of evaluation that has been described above, we collected the following findings.

During the evaluation of the museum simulation, three principal difficulties have been spotted by the users in a manner that they have affected their experience. Approximately 90% of users mentioned that the voice, which was text to speech generated, was very annoying and disengaged them from the experience. Moreover, technical problems, due to localization by beacons often occurred and the experience was not smooth. However, the majority of users who understand that the used technology may include sensors tried to move, wave in front of the exhibits to enable detection and provoke new actions. Finally, the concept of museum simulation turned the procedure hard to understand by some users. Even if we explained the space, two users found it hard to feel the space and stated that they didn't know where or what to look.

Concerning the part of the interaction with the device, the application was found easy to use. The introduction/tutorial was helpful for everyone especially regarding the interaction with the tangible. The options "About" and "Collection" on the bottom menu were chosen less often than the default option "Discover". Four of the users said that they didn't notice the options on the bottom navigation menu. Additionally, five users explained that they didn't choose other options except for the exit, because they felt that the application was guiding them all the time or they didn't need them. Another important observation was that for 4 users it was hard to understand the difference between the screens in front of an exhibit and while walking. This behavior will be discussed further on chapter Future Work.

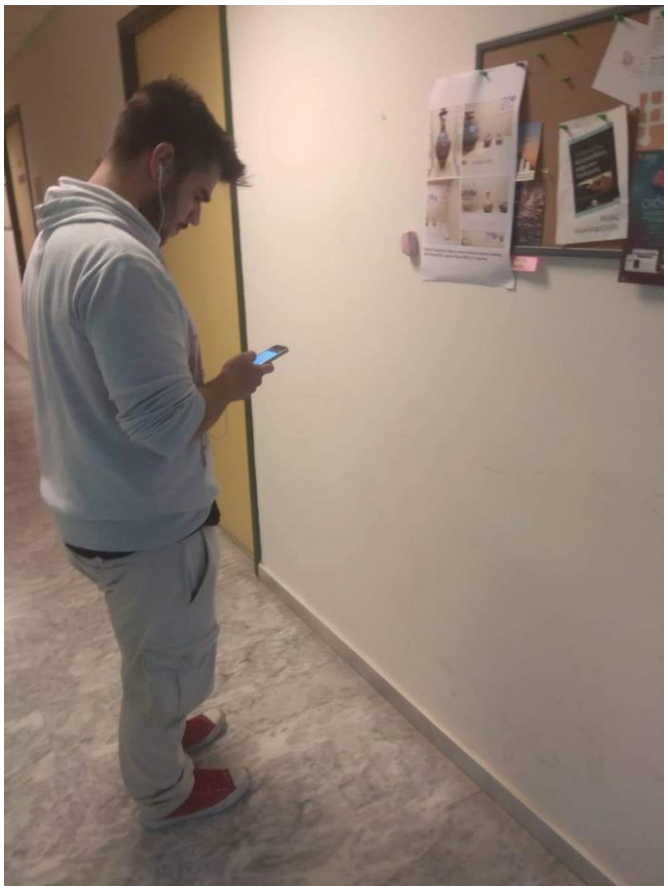


**Figure 56: User during narration mode, reading the text instead of looking at the artifacts**

The tangible interaction received very positive comments. The presentence of the necklace made the experience more interesting for visitors and two of them stated that it increased their curiosity. The paper-made object distracted visitors from the device narration and made them look around. The tangibility drove some users to touch other items of the space because they had the impression that other things around them could trigger tangible interaction. The interaction was easy, but for four users the touch was too sensitive and it took them a while to find out the right way of touching. The only disadvantage of tangible interaction stated by two users is that they were too curious and excited with the tangible that they didn't pay any attention to the narration. Their motive to continue is to play with the tangible.

In general, the total experience with the exception of the above difficulties was commented positively. Story flow and plot was chosen according each user's understanding of experience concept. Regarding characters three users mentioned that the presentence of modern characters, in particular the worker of museum were disengaging. During the interview five users said that the concept of experience was not clear to them from the start and even after the ending they couldn't understand the connection between emotions and their visit. The goal of visit was not clear to them. One user explained that the emotions on tangible complicated the process. Unlocking emotions served as a game for some of them. These users thought that there was a right or wrong way of visit. For whom, the visit was not a game the concept commented as too abstract and they felt insecure if they are missing something.

Regarding users' wayfinding, no difficulties were faced. The audio guided the users towards the right exhibit. Except from one user the rest of them listen to narrations in front of the right exhibit. During the interview, 3 users stated that they didn't find the exhibit

immediately but the app supported them. None user selected the option hint while everyone noticed it.

The environment of the experiment was not ideal in comparison with a real museum. The exhibits were posters and the audio was text to speech so the technical voice was hard to follow. While walking, 5 users were looking around them and not on the screen. However, others were holding the phone in front of them constantly staring and waiting for an action. In front of the exhibits, the majority of visitors were looking all the time the mobile. The voice was the primitive problem for them. Many of the users stopped the audio and read the text. As one user described, her ability to read was quicker than the audio, so that was a problem. Two users explained that they didn't read or listen carefully the narration because they were in a hurry. However, in the interview only 2 users asked for more visuals whereas all the others were satisfied by their absence. In addition, 2 users said that they would prefer exclusively an audio based navigation.

The personalization of this experience was based on choosing what to listen and on giving to this experience the meaning that each one wants. All visitors listened to as many stories as they desired. In particular, number of stories listened varies from 2 to 9 in total. The majority of users chose emotions depending of the exhibit's context while others thought that emotions are different points of view regarding one key character.

Concerning the accuracy between narration and artifacts, 41% of users did understand the connection between the narrations and the artifacts while 41% could not understand it. 16% stated that sometimes they made the connection. This problem lies on the fact that the artifacts were just photos and maybe the percentages were different if the evaluation was done in situ. Moreover, 4 users said that they were not sure about the accuracy of stories, so they were not sure if they could trust the narration and proceed to a connection between artifacts and what they listened.

After the end of the experience, we asked the users if the involvement of emotions and the content of stories affected their experience. 4 users stated that emotions did not have any impact to their experience while 6 answered the opposite. Specifically one user said spontaneously that without emotions the experience would not be the same. When asked about empathy or like/dislike towards characters, only 4 answered that they developed some kind of empathy. They even referred to specific characters as for example Socrates' wife and the midwife.

Regarding the end of experience, i.e. the exit option and the way beacons track user's exit, the opinions were in majority neutral. The exit was not clear that it serves as a review of the experience hence users didn't easily choose to exit. The exit was chosen only when the application reminded to user to exit. Only one user tried to use the share button. Two users liked the fact of statistical review that were presented. Among the users who chose exit, none said that the exit doesn't affect their visit. Three users said that there is no point for them on this step.

Finally, 9 users reported that this experience helped them gain new information about Agora's artifacts. The others said that the environment was not suitable for a museum visit and they couldn't learn something because of time or location.

**Table 4: Answers to question, did emotions affected your experience?**

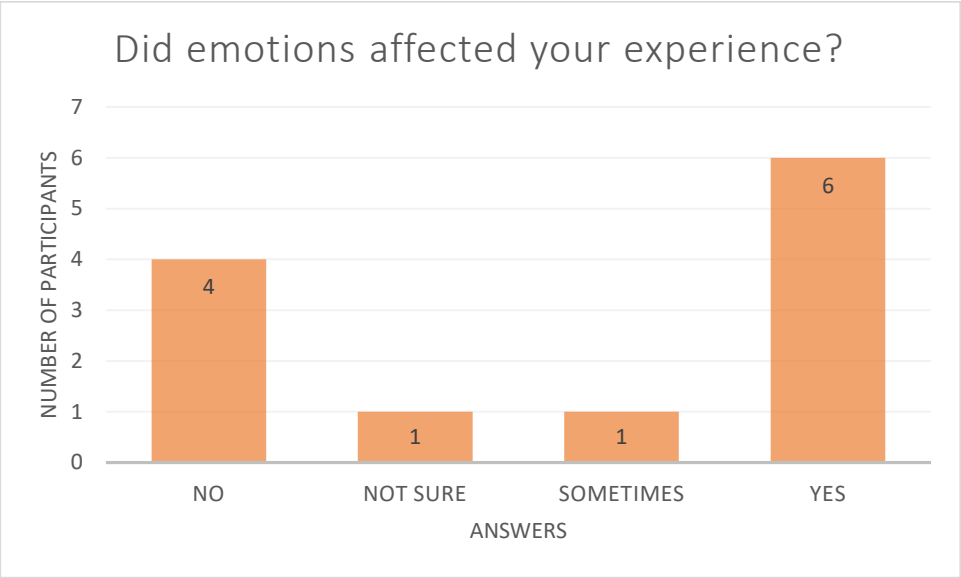
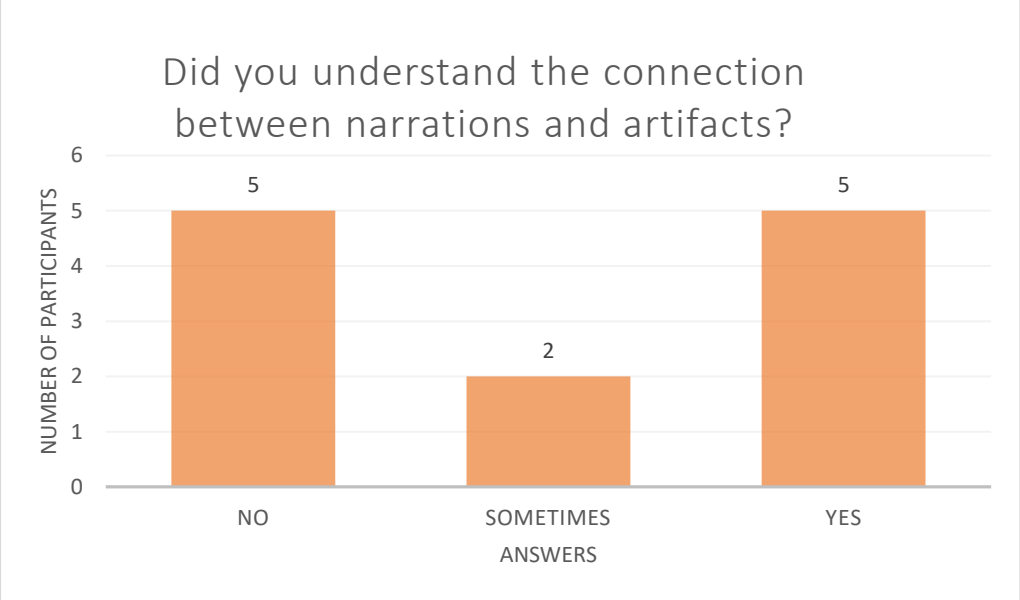



**Table 5: Answers to question, did you understand the connection between narrations and artifacts?**



# 6. SUMMARY & FUTURE WORK

## 6.1 Summary

Through this study, we created a location-aware storytelling experience for the heritage site of Ancient Market of Athens. The initial goal was to examine further the emotive storytelling and its potentials in heritage sites. For the final experience, a combination of tangible interaction and mobile application were used to guide visitors through emotion-driven stories in the museum of Ancient Agora.

In the first chapter, we presented the principal concept of the study and the motives to choose the specific domain of digital cultural heritage. Study's goals and structure are also given.

Then, the literature background, on which this work is based, is analyzed as well as related work that influenced the current project. At the beginning of this chapter, we referenced the emotion and user-centered design. We continued by establishing the concept of digital heritage. Different types of digital heritage were presented and related projects whose findings and problems were acknowledged during the design of the project. As part of our goal, emotion-driven storytelling was our last reference.

In the next part, one of the most important parts of this work was described. The designing chapter presented all the work on this project. The key idea, the audience and a description of the characters and the scenario of the storytelling experience were discussed. Through this phase, we first designed an outdoor experience which inspired the final experience inside the museum of Agora.

Having finished the designing process, we started the implementation of the experience. In the related chapter, the technologies used to carry through this project were presented. Finally, the general structure of our application was described.

On the last part of this project, we examined the basic components of the evaluation part. The evaluation methodology and the procedure that we followed were presented before the analysis of the findings. The presentation of the findings was done in a manner to allow us to better anticipate the positive and negative aspects of this experience and get inspired for future work.

## 6.2 Conclusions

During this thesis we made some observations and reached a series of conclusions. Designing an experience for cultural heritage which focuses on emotion-driven storytelling is a procedure that demands a multidisciplinary team and a very careful work. Digital heritage requires historic information and stories that engage the user quickly. The content of the stories as well as the general context should be brief and on the point. Even if heritage has a lot of stories to offer, it is not easy to make a good story that adapts to the environment of a museum.

A very important method used in this study, related to the design process, is bodystorming [19]. Bodystorming is an essential part of creating and designing an experience of embedded and tangible interaction. The human factor can be unpredictable. Embodied storming posits that we ought to first create the experience of physical performance, not to ideate but to enact experiential awareness. This orientation postpones the particulars of designed forms, functions, and even ideas. The goal of is not just the instrumental formulation of better experience ideas in the context of their use, but we also aim to enact a tangible understanding of the entanglements and actions of human activity in possible future situations.

Story's characters play an important role in storytelling for cultural heritage. Their stories can bridge the gap between the intangible heritage and the modern visitor. From the evaluation interview we observed that users can develop empathy to characters who represent intensive emotions as anger or fear. Even if the concept of emotionally-led interactive stories was not clear to everyone, they gave their own meaning to the process. They didn't approach the heritage as-is but as an entirety of stories. However, it is very important to clarify to users when a story is imaginative or historically accurate because we risk making them approach the heritage as entertainment only. Hence, emotion-driven storytelling was an interesting factor for most of the participants which demands well-designed stories and powerful speech in order to affect the visit experience.

The development of a location-aware application for an indoor location was technically demanding and unpredictable. The use of beacons in an indoor location requires a proper installation and good smartphone. Since beacons belong to sensors' family, their accuracy is not always reliable. However, a location-aware application affected not only the user's wayfinding but also the relation between the user and the smartphone. It was more natural for the users in this way, since they knew that they don't have to look to their phones in order to locate themselves. The applicability of vibration while entering or exiting action at zones of interest was a determinant factor.

In regards to the tangible interaction, we observed that it serves as a very promising interaction approach to digital heritage experiences. The physicality charms immediately users, while the shape of the tangible, the way it works can trigger the curiosity and facilitate the engagement. Physical objects can attach aspects of entertainment or gamification to the experience. Nevertheless, a guidance material such as a tutorial or training which support the interaction is obligatory. Throughout this project, we understand that embodied and tangible interaction, demands a constant design and evaluation. It requires designing for a specific location, and the characteristics of the heritage site should be considered.

Even if we didn't evaluate the experience in situ, visitors considered that the emotive storytelling affected their experience. For some users, the association among emotions and storytelling was not familiar. However, they admit that they gain some new information about the artifacts and the Agora Museum. As a matter of engagement with the heritage, the evaluation that we ran was not useful to draw meaningful conclusions. However, the entire experience motivated visitors to visit the museum, and that appears as a powerful outcome.

Regarding the timeless problem of physical space vs screen, we observed that while screen is a supportive device, i.e. giving instructions about what to do and helping user interact with the artifacts/replicas/tangibles, its role is weakened. By designing a minimalistic application and focusing on tangible interaction, we managed to take the eyes of user from the screen and better understand when users look at the screen and when they do not. A big number of our test visitors even if they weren't at a real museum, they took time looking around and observing the environment. Creating a location-aware experience demands a very close connection between the experience and the environment. The designers should take under consideration the physical space and design for it. However, when text is on the screen, the users prefer to look on it. This point is a part of our future work and discussed in the next chapter.

Although the literature study implies the need for a personalized ending, we discovered that the end of our experience didn't play any primitive role to this kind of experience. The review of choices through the experience was commented positively, but the profile generation based on user's selections didn't impress the users. The personalized ending

should become more meaningful for the visitors so that a part of the experience should be able to be taken away. Considering the fact that the experience involves emotions, the option to get a more interactive and designed review is necessary.

## 6.3 Future Work

As mentioned at the outset, Greece is a country rich in heritage sites. Since this project had a promising outcome, it could be further improved to create a more complete experience.

The user evaluation did not run in the museum area. Consequently, a notable first step of future work should be the evaluation of the experience in situ. In a museum simulation, the user could be biased and hardly adapted to the environment. An evaluation in situ will help us investigate if the results are similar to the ones observed in our first evaluation and will answer whether the experience can stand only at indoor locations or not. In case the visitors successfully experience the heritage without its actual presentence, then this experience could be applied to un-stewarded archaeological sites.

The small amount of test participants means that the test results of this study should not be extrapolated to draw general conclusions until more tests are performed. If time allowed, a more in-depth interview process with individual interviews could have led to a more complete feedback about the digital museum's experience. Since emotion-driven storytelling is a new approach to digital heritage, the offered means, especially during the evaluation part, are not sufficient. We should run further tests and questionnaires that focus more on visitors' immersion and engagement after an insight visit.

Because the user test interviews were conducted in person, it is plausible that the feedback was often biased. As the participants knew that they faced the creators of the experience, they might have been more likely to give positive feedback. Additionally, a digital heritage experience is not usual to the native audience. Hence, the majority of them could be at first excited, but then used and bored to the procedure. It is not clear if the users would repeat the experience during another museum visit.

For the current project's state, we count two areas of interest. To achieve a better image for the entire experience, we have to improve the technical aspects of this project. The characters should be recorded by actors in order to make the experience more natural and the detection of users should be improved in order to turn the visit more automatic. Efforts should focus on the general experience aspects rather than the application. For instance the interactive map is not necessary as the majority of visitors follow the instructions on screen without questioning.

The second topic of future work lies on the few aspects of the application that require further development. In the first place, we should clarify the difference between the walking menu and the standing menu. In case a user exits an area of interest and forgets to return to the walking menu, while user tracking is executed, the application should give her a feedback. Moreover, during the narration part, an important improvement would be the avoidance of text display. A possible solution could be displaying text only in case user demands it, or creating of a subtitle option while the narration is performing.

# ANNEX I: CODE

## JSON file

The following part presents the JSON file that we used to save the data of stories and chapters.

To retrieve the external data and save them to project's global range, a http class was created. This class is responsible for URL connection with the JSON file and the data-handling.

```
public class HttpHandler {

    private static final String TAG = HttpHandler.class.getSimpleName();

    public HttpHandler() {
    }

    public String makeServiceCall(String reqUrl) {
        String response = null;
        Log.e(TAG, "Start service call");
        try {
            URL url = new URL(reqUrl);
            HttpURLConnection conn = (HttpURLConnection) url.openConnection();
            conn.setRequestMethod("GET");
            // read the response
            InputStream in = new BufferedInputStream(conn.getInputStream());
            response = convertStreamToString(in);
            Log.e(TAG, "Succeed");
        } catch (MalformedURLException e) {
            Log.e(TAG, "MalformedURLException: " + e.getMessage());
        } catch (ProtocolException e) {
            Log.e(TAG, "ProtocolException: " + e.getMessage());
        } catch (IOException e) {
            Log.e(TAG, "IOException: " + e.getMessage());
        } catch (Exception e) {
            Log.e(TAG, "Exception: " + e.getMessage());
        }
        return response;
    }

    private String convertStreamToString(InputStream is) {
        BufferedReader reader = new BufferedReader(new InputStreamReader(is));
        StringBuilder sb = new StringBuilder();

        String line;
        try {
            while ((line = reader.readLine()) != null) {
                sb.append(line).append('\n');
            }
        } catch (IOException e) {
            e.printStackTrace();
        } finally {
            try {
```

```
                is.close();
            } catch (IOException e) {
                e.printStackTrace();
            }
        }

        return sb.toString();
    }
}
```

**Proximity zones and Proximity Observer**

In order to support Estimote libraries to the application we had to declare the following dependencies on Proximity SDK, and a little helper library that we'll use for requesting location permissions.

```
dependencies {
    implementation fileTree(dir: 'libs', include: ['*.jar'])
    implementation 'com.android.support:appcompat-v7:27.0.0'
    implementation 'com.android.support.constraint:constraint-layout:1.1.2'
    implementation 'com.android.support:support-v4:27.0.0'
    implementation 'com.android.support:design:27.0.0'
    testImplementation 'junit:junit:4.12'
    androidTestImplementation 'com.android.support.test:runner:1.0.2'
    androidTestImplementation 'com.android.support.test.espresso:espresso-core:3.0.2'
    implementation 'com.estimote:proximity-sdk:0.3.1'
    implementation 'com.estimote:mustard:0.2.1'

    implementation "android.arch.lifecycle:extensions:1.1.0"
    implementation "android.arch.lifecycle:viewmodel:1.1.0"
}
```

To set up the Proximity Observer we have firstly generate a token on cloud.estimote.com/#/apps/add . Once App ID and Token are ready the application has to get connected to the Estimote cloud using the following code segment.

```
public class MyApplication extends Application {
    public CloudCredentials cloudCredentials =
            new EstimoteCloudCredentials("madgik-fernweh-s-proximity-88y",
"d0f830543efbfa65b45a4edea2855eb0");
}
```

To request permissions to access the GPS and the Bluetooth for beacons, we used the RequirementsWizardFactory provided by Estimote proximity library.

```
//Set the requirements for beacons
RequirementsWizardFactory
        .createEstimoteRequirementsWizard()
        .fulfillRequirements(getActivity(),
                new Function0<Unit>() {
                    @Override
                    public Unit invoke() {
                        Log.d("app", "requirements fulfilled");
                        startProximityContentManager();
                        return null;
```

```
            }
        },
        new Function1<List<? extends Requirement>, Unit>() {
            @Override
            public Unit invoke(List<? extends Requirement> requirements) {
                Log.e("app", "requirements missing: " + requirements);
                return null;
            }
        },
        new Function1<Throwable, Unit>() {
            @Override
            public Unit invoke(Throwable throwable) {
                Log.e("app", "requirements error: " + throwable);
                return null;
            }
        });
```

Before defining a proximity zone, we have to set a proximity observer and then add the proximity zones.

```
cloudCredentials = ((MyApplication) getActivity().getApplication()).cloudCredentials;


ProximityObserver proximityObserver = new
ProximityObserverBuilder(getActivity().getApplicationContext(), cloudCredentials)
        .withOnErrorAction(new Function1<Throwable, Unit>() {
            @Override
            public Unit invoke(Throwable throwable) {
                Log.e("app", "proximity observer error: " + throwable);
                return null;
            }
        })
        .withBalancedPowerMode()
        .build();
```

In order to create a proximity zone, “enter” and “exit” actions should be defined. Then, the zone is ready to be added to the proximity observer.

```
ProximityZone zone = proximityObserver.zoneBuilder()
        .forAttachmentKeyAndValue("madgik-fernweh-s-proximity-88y", "example-
proximity-zone")
        .inCustomRange(1) // 1 meters range
        .withOnEnterAction(new Function1<ProximityAttachment, Unit>() {
            @Override
            public Unit invoke(ProximityAttachment attachment) {
                exit = false;
                String title = attachment.getPayload().get("madgik-fernweh-s-proximity-
88y/title");

fragment_view.findViewById(R.id.fragm_layout).setBackgroundColor(getResources().g
etColor(R.color.detectBeacon));
                bt_more.setVisibility(View.GONE);
                img.setVisibility(View.GONE);
                if (title == null) {
```

```
                title = "ERROR";
                textView.setText(title);
            }
            else {
                //Find story of the area
                String story_title = Utils.getStoryID(title);
                //Find story from Data
                Log.e(TAG, "size of array is "+ storyInfosArrayList.size());

                current_story =
ViewModelProviders.of(getActivity()).get(TotalSharedDataViewModel.class).getStory(st
ory_title);

                artifact = story_title;
                state = "search";
                String audio_src;

                //Set screen text to Come closer
                textView.setText("ΠΛΗΣΙΑΖΕΙΣ, ΨΑΞΕ ΚΑΛΥΤΕΡΑ");
                //Play the sound of character calling
                //Start audio calling
                if("Socrates".equals(story_title)){
                    audio_src="calling_socrates";
                }
                else{
                    audio_src = "calling_pregnant";
                }
                Uri uri = Uri.parse("android.resource://" +
getActivity().getApplicationContext().getPackageName() +  "/" + "raw" +"/"+ audio_src);
                Log.e("myReport", "Uri:"+uri);
                if(active){
                    mp = MediaPlayer.create(getContext(), uri);
                    mp.start();
                }

                bt_found.setVisibility(View.VISIBLE);
                bt_found.setOnClickListener(new View.OnClickListener() {
                    @Override
                    public void onClick(View view) {
                        handleEnterAction();
                    }
                });

            }
            return null;
        }
    })
    .withOnExitAction(new Function1<ProximityAttachment, Unit>() {
        @Override
        public Unit invoke(ProximityAttachment proximityContext) {
            exit = true;
```

```
            state = "walk";
            textView.setText("Ξεκίνα να περπατάς");
            textView.setTextColor(getResources().getColor(R.color.black));
            textViewSmall.setVisibility(View.GONE);
            //If all stories and sub-stories are done
            if(isFinished()){
                textView.setText("Έχεις ακούσει όλες τις ιστορίες, μπορείς να φύγεις");
            }

            if(mp!=null){
                mp.stop();
            }


fragment_view.setBackgroundColor(getResources().getColor(R.color.defaultBackground));
            bt_more.setVisibility(View.GONE);
            bt_found.setVisibility(View.GONE);
            img.setVisibility(View.GONE);

            //Inform total story list about this change

ViewModelProviders.of(getActivity()).get(TotalSharedDataViewModel.class).setStory(current_story);


            current_story = null;
            current_storyUserDataList = null;
            return null;
        }
    })
    .create();

proximityObserver.addProximityZone(zone);
proximityObserverHandler = proximityObserver.start();
```

**NFC reading**

All android activities handle NFC reading in order to prevent android system to handle the reading. To handle NFC actions the following functions are necessary to each activity:

```
private void initNFC(){
    mNfcAdapter = NfcAdapter.getDefaultAdapter(this);
}

public void onDialogDisplayed() {
    isDialogDisplayed = true;
}

public void onDialogDismissed() {
    isDialogDisplayed = false;
}
```

```
@Override
protected void onNewIntent(Intent intent) {
    Tag tag = intent.getParcelableExtra(NfcAdapter.EXTRA_TAG);

    Log.d(TAG, "onNewIntent: "+intent.getAction());

    if(tag != null) {
        Toast.makeText(this,"Καμία δραστηριότητα", Toast.LENGTH_SHORT).show();
        Ndef ndef = Ndef.get(tag);
        onDialogDisplayed();
        if (isDialogDisplayed) {
            onNfcDetected(ndef);
        }
    }
}

public void onNfcDetected(Ndef ndef){
    readFromNFC(ndef);
}


@Override
protected void onResume() {
    super.onResume();
    IntentFilter tagDetected = new
IntentFilter(NfcAdapter.ACTION_TAG_DISCOVERED);


    IntentFilter ndefDetected = new
IntentFilter(NfcAdapter.ACTION_NDEF_DISCOVERED);


    IntentFilter techDetected = new
IntentFilter(NfcAdapter.ACTION_TECH_DISCOVERED);


    IntentFilter[] nfcIntentFilter = new
IntentFilter[]{techDetected,tagDetected,ndefDetected};

    PendingIntent pendingIntent = PendingIntent.getActivity(
            this, 0, new Intent(this,
getClass()).addFlags(Intent.FLAG_ACTIVITY_SINGLE_TOP), 0);


    if(mNfcAdapter!= null)
        mNfcAdapter.enableForegroundDispatch(this, pendingIntent, nfcIntentFilter, null);

}
```

The NFC reading function during tangible interaction is presented below. Background is changing according to the tangible side's color and related text is displayed. After a successful NFC read, a button is revealed. By pressing this button, the related to color/emotion chapter is shown.

```
private void readFromNFC(Ndef ndef) {

if(!nfc_active) return;
if(ndef==null)      return;
    try {
        ndef.connect();
        NdefMessage ndefMessage = ndef.getNdefMessage();
        String g_message;
        if (ndefMessage == null){
            return;
        }
        message = new String(ndefMessage.getRecords()[0].getPayload());

        if("love".equals(message)){

fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.colorLove));
            g_message = "Η αγάπη";
            blacktext = true;
            mTvMessage.setTextColor(getResources().getColor(R.color.black));
            mTvMessage.setText(g_message);
        }
        else if("fear".equals(message)){

fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.colorFear));
            g_message = "Ο φόβος";
            blacktext = false;
            mTvMessage.setTextColor(getResources().getColor(R.color.white));
            mTvMessage.setText(g_message);
        }
        else if("joy".equals(message)){

fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.colorJoy));
            g_message = "Η χαρά";
            blacktext = true;
            mTvMessage.setTextColor(getResources().getColor(R.color.black));
            mTvMessage.setText(g_message);
        }
        else if("jealousy".equals(message)){

fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.colorDisgust));
            g_message = "Η ζήλεια";
            blacktext = false;
            mTvMessage.setTextColor(getResources().getColor(R.color.white));
            mTvMessage.setText(g_message);
        }
        else if("exit".equals(message)){
```

```
fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.colorAgora));
            g_message = "Η αγορά";
            blacktext = true;
            mTvMessage.setTextColor(getResources().getColor(R.color.black));
            mTvMessage.setText(g_message);
        }
        else if("admiration".equals(message)){

fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.colorAdmiration));
            g_message = "Ο θαυμασμός";
            blacktext = true;
            mTvMessage.setTextColor(getResources().getColor(R.color.black));
            mTvMessage.setText(g_message);
        }
        else if("anger".equals(message)){

fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.colorAnger));
            g_message = "Ο θυμός";
            blacktext = false;
            mTvMessage.setTextColor(getResources().getColor(R.color.white));
            mTvMessage.setText(g_message);
        }
        else if ("boredom".equals(message)){

fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.colorBoredom));
            g_message = "Η πλήξη";
            blacktext = true;
            mTvMessage.setTextColor(getResources().getColor(R.color.black));
            mTvMessage.setText(g_message);
        }
        else {

fragment_view.findViewById(R.id.nfc_reading_layout).setBackgroundColor(getResourc
es().getColor(R.color.grey));
            g_message = "Προσπάθησε ξανα";
            mTvMessage.setText(g_message);
        }
        ndef.close();

    } catch (IOException | FormatException e) {
        e.printStackTrace();
        return;
    }

    messageRead = message;
    if(blacktext){
        bt_continue_black.setVisibility(View.VISIBLE);
```

```
        bt_continue_white.setVisibility(View.GONE);
        imgNecklaceWhite.setVisibility(View.GONE);
        imgNecklaceBlack.setVisibility(View.VISIBLE);
    }
    else{
        bt_continue_white.setVisibility(View.VISIBLE);
        bt_continue_black.setVisibility(View.GONE);
        imgNecklaceWhite.setVisibility(View.VISIBLE);
        imgNecklaceBlack.setVisibility(View.GONE);
    }
    final String finalMessage = message;
    bt_continue_white.setOnClickListener(new View.OnClickListener() {
        @Override
        public void onClick(View view) {
            if(mp!=null)
                mp.stop();
            //Proceed to Narration
            act_narration = true;
            current_chapter = current_story.chapter_search(finalMessage);
            character = current_chapter.getCharacter();
            //Keep and send emotion&character
            display_chapter(current_chapter);
        }
    });

    bt_continue_black.setOnClickListener(new View.OnClickListener() {
        @Override
        public void onClick(View view) {
            if(mp!=null)
                mp.stop();
            //Proceed to Narration
            act_narration = true;
            current_chapter = current_story.chapter_search(finalMessage);
            character = current_chapter.getCharacter();
            //Keep and send emotion&character
            display_chapter(current_chapter);
        }
    });
}
```

# ANNEX II: Final Experience

To develop an application demands continuous design and evaluation. After presenting the designing process on chapter 4 and evaluating in small groups the designed experience, in this section we are going to present the tangible and the experience as it was formed and used at the final evaluation.

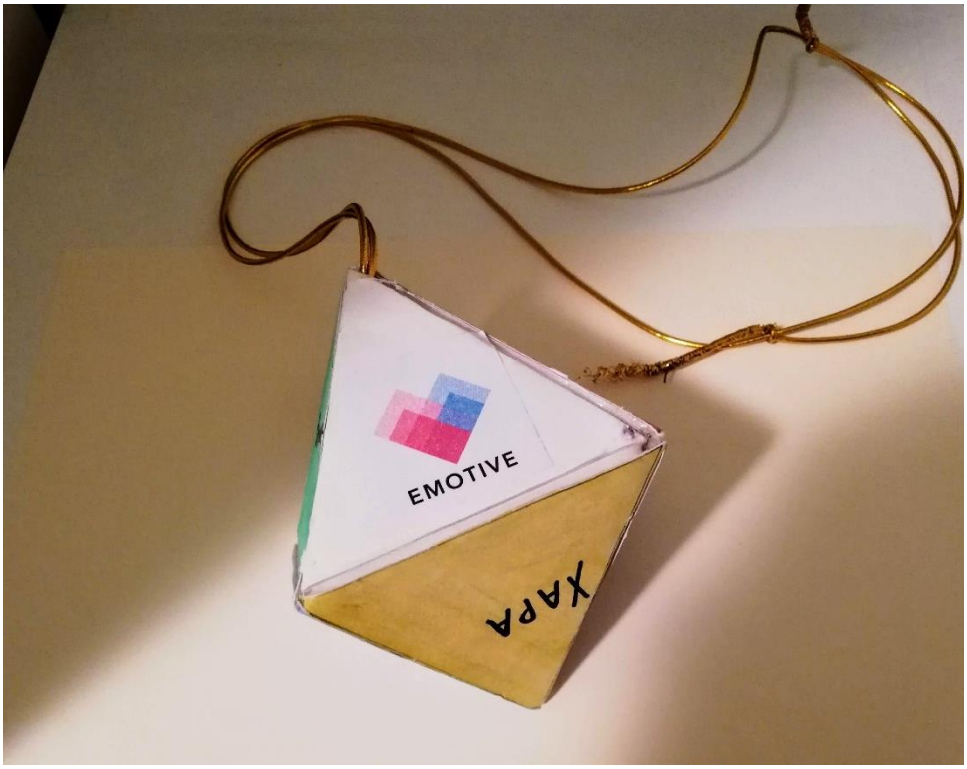



**Figure 57: Final form of tangible**

At first, we built a new bigger tangible prototype, in order to make easier the interaction with the mobile device and to embed the NFC tags. The tangible was designed as shown below.

In the beginning of the experience there is an introductory part to the experience's concept and a short tutorial on how to use the tangible interaction. The steps that we created were five. Within this part the user has the option to try interacting with the tangible and understand how it works. The following screens are part of the introduction part. The option to skip the introduction is given.


**Figure 58: First welcome screen of the application**

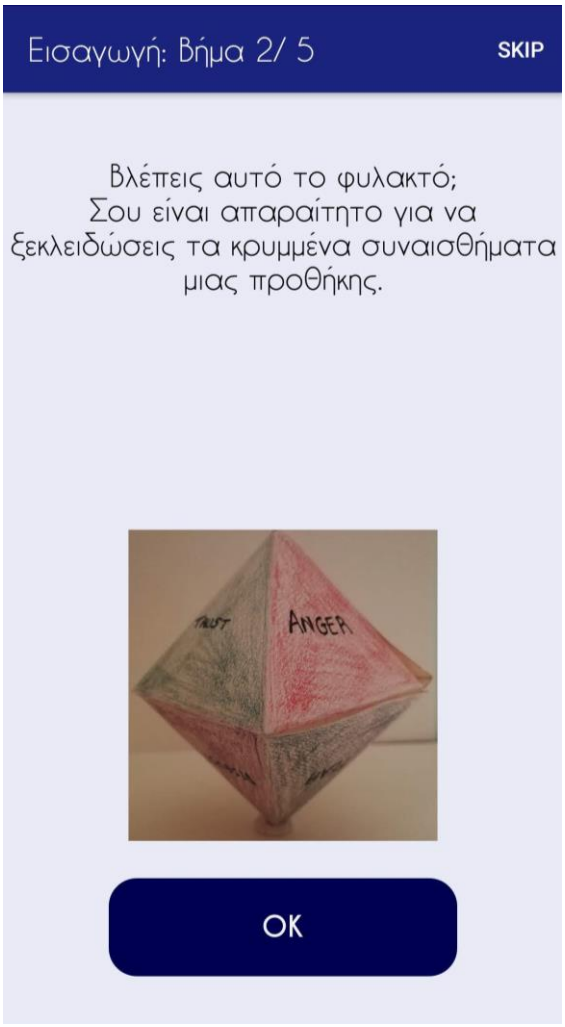



**Figure 59: Screen of step 2 where the usability of tangible is explained**

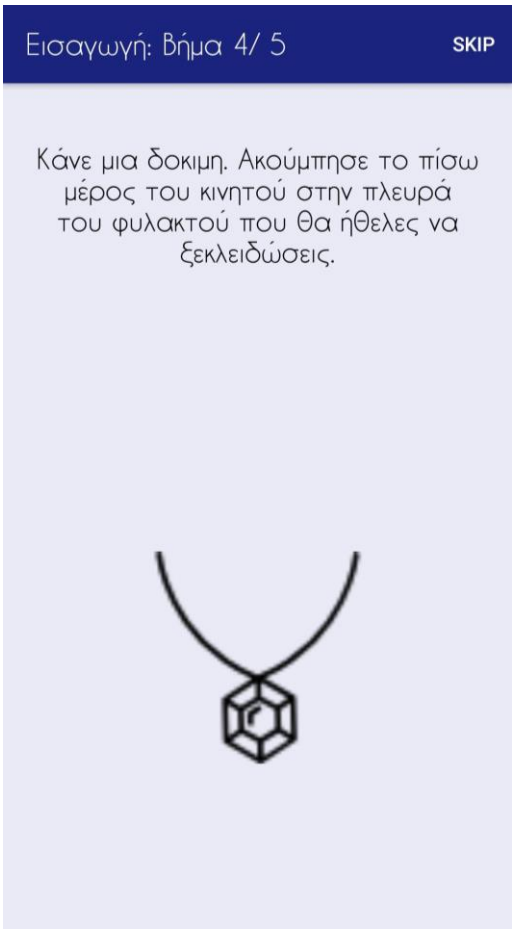



**Figure 60: Screen of step 4, a trial of tangible's use**

The main experience, as it was presented at chapters 4 and 5, consist of two different screen layouts, one shown while walking and one shown during unlocking emotions.

Regarding the menu that is shown while walking, the options "Collection" and "Exit" are offered. The main screen, as it is shown below, gives instructions to users such as walk, search, and stop. In any of these steps, the option "Hint" is offered in case the user needs help or she is stuck.

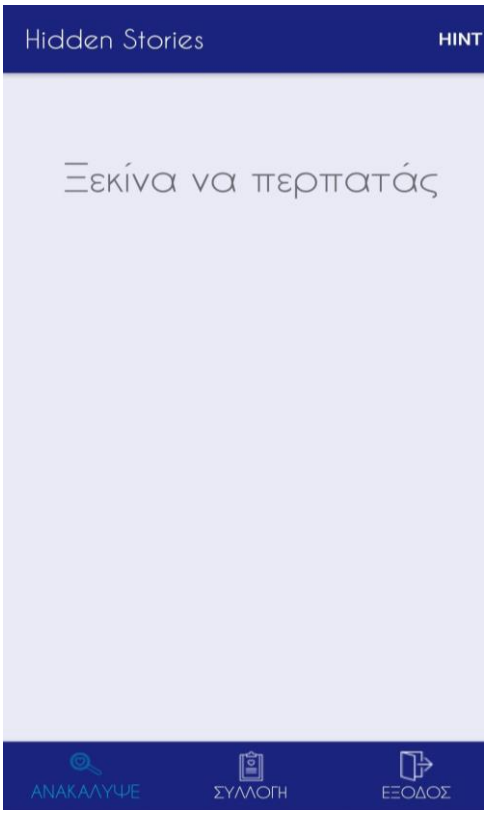



**Figure 61: Menu while user is walking**

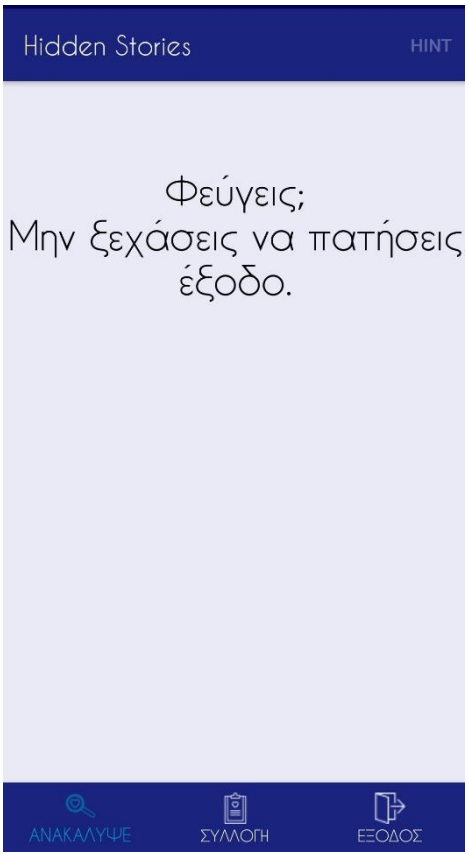



**Figure 62: Screen when user attempts to exit the place without perform an exit in the application**

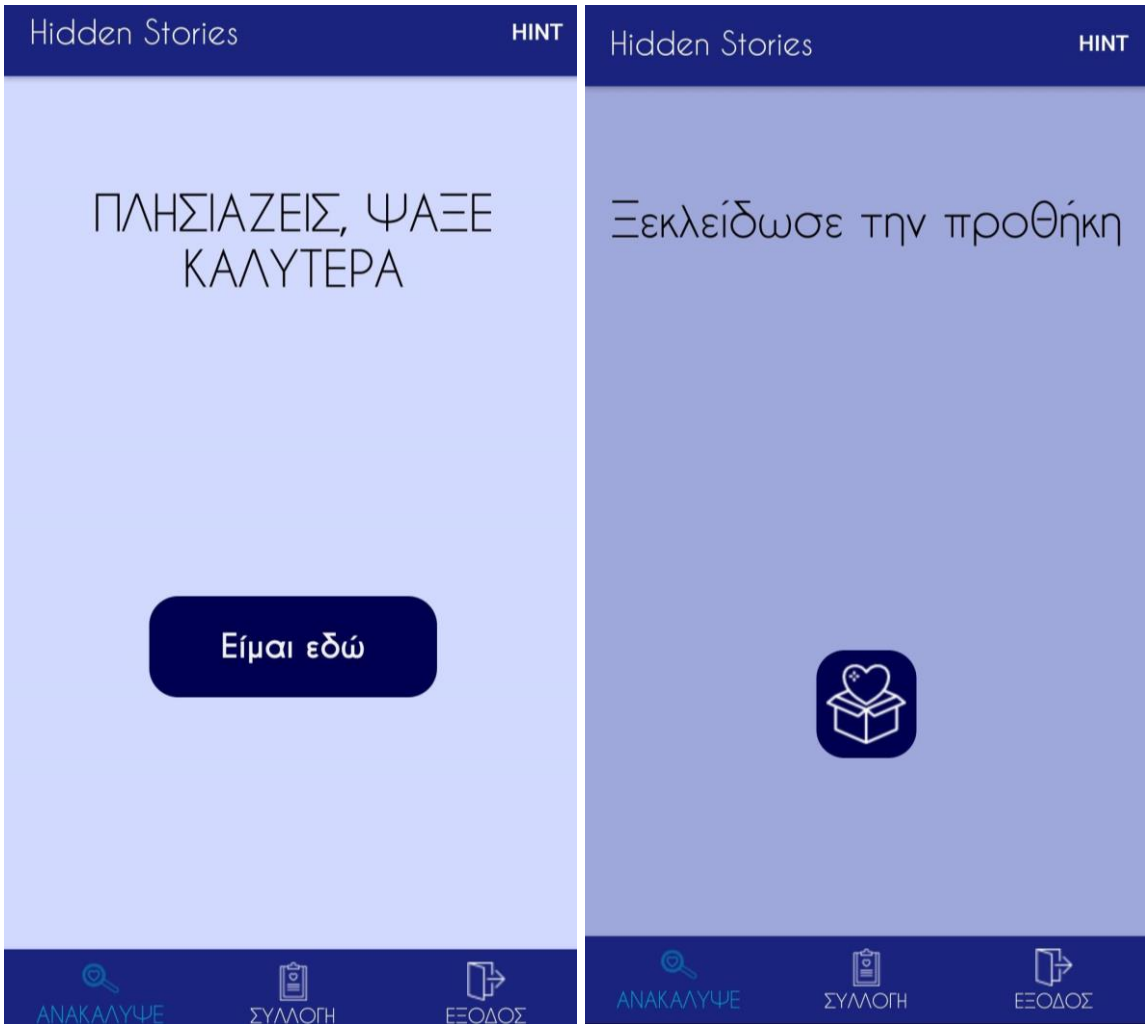



**Figure 63: Screens when user is near an exhibit (left) and when she found the exhibit (right)**

In case that the user found the artifact and unlocked the exhibit, she is now ready to interact with the tangible to find out stories about the artifacts. On the menu of this state, options “Collection” and “About” are offered. The “About” option is similar to the narration option but it concerns the informational part of the artifacts. The main option “Discover” consists from three parts. The interaction with the tangible, the related narration and the revelation of the character hidden behind the narration heard.


**Figure 64: Screen when user has to interact with tangible**


**Figure 65: Screen after a successful interaction with tangible, admiration is chosen**


**Figure 66: Narration on the left and revelation of character talking on the right**

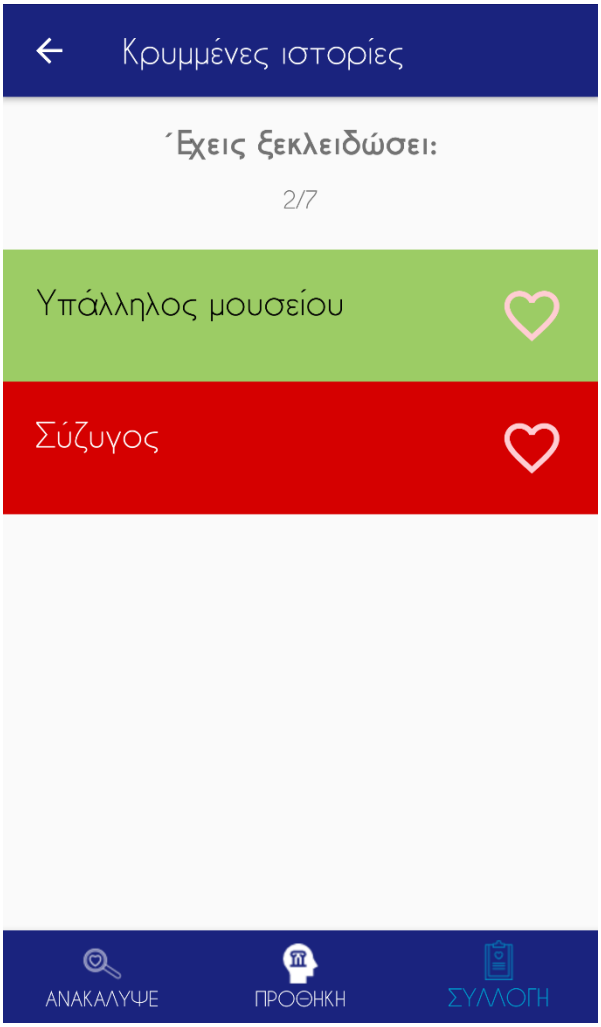



**Figure 67: My Collection option**

Finally, if users choose to exit the experience or they are near the exit, exit option opens. In case they exit, a review of their visit choices is displayed while their personal profile is generated.


**Figure 68: Review of visit and the profile of user**

# ANNEX III: INVITATION FOR PARTICIPATION IN THE EVALUATION

In this annex the mail invitation for participation in the evaluation of this study is cited below.

Καλημέρα και καλή εβδομάδα,

η φοιτήτρια Ειρήνη Κακλοπούλου έχει σχεδιάσει και υλοποιήσει ως πτυχιακή εργασία μια εμπειρία επίσκεψης στο μουσείο της Αρχαίας Αγοράς μέσω ψηφιακής εφαρμογής αφήγησης ιστορίων με συναισθήματα και απτά αντικείμενα.

Στα πλαίσια της αξιολόγησης της εμπειρίας, θα θέλαμε να σας προσκαλέσουμε, την Τετάρτη 17 Οκτωβρίου μεταξύ 16:00 και 18:00, να δοκιμάσετε την εφαρμογή αυτή, δυστυχώς όχι στην Αρχαία Αγορά, αλλά στον διάδρομο έξω από το γραφείο Α51. Μετά την αλληλεπίδραση θα ακολουθήσει μια σύντομη συνέντευξη σχετικά με την εμπειρία.

Εάν σας ενδιαφέρει και μπορείτε, παρακαλούμε να επιλέξτε την ώρα που σας εξυπηρετεί από τις διαθέσιμες: https://doodle.com/poll/b7mi4vhpavs9e33z

Ευχαριστώ πολύ!

Μαρία Ρούσσου

# ANNEX IV: IN SITU USE OF FINAL EXPERIENCE

At the end of this study, we had the opportunity to run the final designed experience inside the museum of Ancient Agora. A small multidisciplinary group of museum's staff participated in this test. Since they come from the museum's perspective, they could not participate in an evaluation as visitors. However, these people know the museum and its aspects profoundly. Their comments and contribution during the experience were more than useful regarding the improvement of the current experience as a part of future work.

The photos presented below were taken during their experiences inside the museum after their consent.


**Figure 69: Participant at the beginning of the experience**

**Figure 70: Participant in front of the exhibit of rich pregnant woman listens the narration related to indifference**

**Figure 71: Participant in front of the exhibit of Socrates listens the narration related to indifference**


**Figure 72: Participant on exit reads his profile review**


**Figure 73: Participant interacts with tangible**


**Figure 74: Participant explores her options in order to unlock an emotion**

# REFERENCES


[1] S. Poole, “Ghosts in the Garden: locative gameplay and historical interpretation from below#,” *Int. J. Herit. Stud.*, vol. 24, no. 3, pp. 300–314, 2018.

[2] D. Petrelli and S. O’Brien, “Phone vs . Tangible in Museums : A Comparative Study,” *2018 CHI Conf. Hum. Factors Comput. Syst.*, pp. 1–12, 2018.

[3] B. Wyman, S. Smith, D. Meyers, and M. Godfrey, “Digital Storytelling in Museums: Observations and Best Practices,” *Curator Museum J.*, vol. 54, no. 4, pp. 461–468, 2011.

[4] R. Damiano, C. Gena, V. Lombardo, F. Nunnari, and A. Pizzo, *A stroll with Carletto: Adaptation in drama-based tours with virtual characters*, vol. 18, no. 5. 2008.

[5] D. Petrelli, N. Dulake, M. T. Marshall, A. Pisetti, and E. Not, “Voices from the War: Design As a Means of Understanding the Experience of Visiting Heritage,” *Proc. 2016 CHI Conf. Hum. Factors Comput. Syst.*, pp. 1033–1044, 2016.

[6] C. Heath, “Displacing the object : mobile technologies and interpretive resources DISPLACING THE OBJECT : MOBILE TECHNOLOGIES AND INTERPRETIVE RESOURCES Work , Interaction and Technology Research Group ( WIT ) The Management Centre - King ’ s College London , UK,” no. August 2010, 2015.

[7] D. Mcgookin, S. Brewster, and J. Bergstrom-lehtovirta, “Shaking the Dead : Multimodal Location Based Experiences for Un-Stewarded Archaeological Sites,” *Nord. Conf. Human-Computer Interact.*, pp. 199–208, 2012.

[8] Y. Rogers *et al.*, “Things aren’t what they seem to be,” in *Proceedings of the conference on Designing interactive systems processes, practices, methods, and techniques - DIS ’02*, 2002, p. 373.

[9] D. McGookin, Y. Vazquez-Alvarez, S. Brewster, and J. Bergstrom-Lehtovirta, “Shaking the dead,” in *Proceedings of the 7th Nordic Conference on Human-Computer Interaction Making Sense Through Design - NordiCHI ’12*, 2012, p. 199.

[10] M. Roussou and A. Katifori, “Flow, Staging, Wayfinding, Personalization: Evaluating User Experience with Mobile Museum Narratives,” *Multimodal Technol. Interact.*, vol. 2, no. 2, p. 32, 2018.

[11] M. T. Marshall *et al.*, “Using Tangible Smart Replicas as Controls for an Interactive Museum Exhibition,” *Tangible Embodied Interact.*, no. February, pp. 159–167, 2016.

[12] A. Galani and M. Chalmers, “Far Away is Close at Hand: SHARED MIXED REALITY MUSEUM EXPERIENCES FOR LOCAL AND REMOTE MUSEUM COMPANIONS,” *ICHIM03, Int. Cult. Herit. Informatics Meet.*, pp. 1–20, 2003.

[13] M. Danks, M. Goodchild, K. Rodriguez-Echavarria, D. B. Arnold, and R. Griffiths, “Interactive Storytelling and Gaming Environments for Museums: The Interactive Storytelling Exhibition Project,” *Technol. E-Learning Digit. Entertain.*, pp. 104–115.

[14] D. Petrelli and A. Schmidt, “Integrating Material and Digital: A New Way for Cultural Heritage,” vol. 20, pp. 58–63, 2013.

[15] D. Petrelli, N. Dulake, M. Willox, F. Caparrelli, and R. Goldberg, “Prototyping Tangibles: Exploring Form and Interaction,” *Proc. 8th Int. Conf. Tangible, Embed. Embodied Interact. - TEI’14*, pp. 41–48, 2014.

[16] V. Lombardo, R. Damiano, and M. M. Park, “Storytelling on a mobile device for museum guidance,” *October*, no. Ashley 2007, pp. 1–17, 2010.

[17] H. Zhao, J. J. Zhang, and S. Mcdougall, “LNCS 6972 - Emotion-Driven Interactive Digital Storytelling,” *LNCS*, vol. 6972, pp. 22–27, 2011.

[18] S. Perry, M. Economou, H. Young, M. Roussou, and L. Pujol, “Moving beyond the virtual museum: Engaging visitors emotionally,” *Proc. 2017 23rd Int. Conf. Virtual Syst. Multimedia, VSMM 2017*, vol. 2018–Janua, pp. 1–8, 2018.

[19] D. Schleicher, P. Jones, and O. Kachur, “Bodystorming as embodied designing,” *Interactions*, vol. 17, no. 6, p. 47, 2010.

[20] R. Hardy and E. Rukzio, “Touch & interact: touch-based interaction of mobile phones with displays,” *Proc. MobileHCI*, pp. 245–254, 2008.

[21] J. Reid, R. Hull, B. Clayton, T. Melamed, and P. Stenton, “A research methodology for evaluating location aware experiences,” *Pers. Ubiquitous Comput.*, vol. 15, no. 1, pp. 53–60, 2011.

[22] V. Roto, A. Vermeeren, K. Väänänen-vainio-mattila, and E. L.-C. Law, “User Experience Evaluation – Which Method to Choose ?,” *Ifip Int. Fed. Inf. Process.*, vol. 6949, pp. 714–715, 2011.

[23] S. H. C. Houde, What do prototypes prototype? Handbook of Human Computer Interaction, (2nd Ed) Elsevier Science, (1997), 1997

[24] T. S. Rikke Dam, (https://www.interaction-design.org) 6 October 2018. Available: https://www.interaction-design.org/literature/article/prototyping-learn-eight-common-methods-and-best-practices.
[25] P. G. Jeremy Miles, A Handbook of Research Methods for Clinical and Health Psychology, United States: Oxford University Press Inc, 2015.