



DEPARTMENT OF COMPUTER SCIENCE

A User-Centered Application for Museums to Improve Lives of Individuals with Dementia

Innovation at the Intersection of Dementia Care and Museum Accessibility



A dissertation submitted to the University of Bristol in accordance with the requirements of the degree
of Bachelor of Science in the Faculty of Engineering.

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Abstract

Background

Due to the high prevalence of dementia and the absence of a definitive cure, non-medical treatments have become increasingly common and have demonstrated efficacy in improving the well-being of individuals with dementia and their caregivers. Engaging activities within museum environments have emerged as a promising medium for delivering such non-pharmacological interventions, simultaneously offering enriching social experiences for visitors. The integration of mobile technology within these settings has the potential to enhance the accessibility and effectiveness of these therapeutic interventions.

Aims

The objective is to design a tablet application aimed at enhancing museum viewing engagement for individuals with dementia and their informal carers. The application aims to strengthen the relationship between them, boost social confidence, and ultimately improve their overall well-being.

Methods

During the design process, I utilized the Spiral Model and combined it with User-Centered Design (UCD) principles. The design prototype underwent three iterative cycles, each of which involved planning, risk analysis, building, and evaluation. The plans and evaluations integrated the data collected during user studies. For the final evaluation, an iOS iPad application was built based on the prototype, and it was tested in a real-world activity at a museum.

Conclusion

The digital app has the potential to improve accessibility and enhance the experience of visiting museums for individuals with dementia. It has been suggested that the use of the app may alleviate social withdrawal between caregivers and individuals with dementia. However, further research is necessary to investigate the long-term social confidence improvements, and this requires extended observation periods and larger sample sizes to obtain reliable results.

Keywords

Dementia, Museum, Reminiscence therapy, Art therapy, Informal caregivers, Dementia-friendly mobile application

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Ethics Statement

An ethics application for this project was reviewed and approved by the faculty research ethics committee as application 0334.

Chapter 1

Introduction

Addressing the Global Dementia Crisis: Non-Medical Interventions

Dementia constitutes a substantial contributor to mortality, disability, and dependence among the elderly population on a global scale [3], thereby imposing a significant burden on medical resources. As of 2023, the worldwide population of individuals living with dementia stands at 55 million, with an annual increase of ten million projected [3]. This trend is estimated to persist, culminating in a projected 115 million individuals with dementia by the year 2050 [4]. Therefore, the management of dementia demands heightened attention.

Currently, the treatment of dementia is predominantly focused on medication and is primarily administered by medical professionals [5]. The high volume of demand for medical care places a burden on medical institutions such as hospitals and care homes [6]. The development of non-medical treatment has the potential to alleviate the burden on hospitals and care homes by reducing the need for medical interventions. Consequently, research aimed at enhancing non-drug interventions that consider the diverse needs of individuals with dementia from a holistic perspective is of paramount importance. By doing so, it may be possible to slow down the progression of the disease in early-stage dementia patients and encourage increased utilization of home care [7].

Challenges and Impacts of Informal Dementia Caregiving

Due to the high cost and demands on hospital resources, family care has become a more prevalent approach for individuals in the early stages of dementia [8]. Informal caregivers, including spouses and children, assume the responsibility of caring for individuals with dementia, which exerts a significant workload that affects their personal lives. As a result, they may experience negative mood symptoms, such as depression and stress [9]. The burden and stress associated with caregiving can have a negative impact on the relationship between caregivers and individuals with dementia, ultimately leading to a decline in relationship quality following a dementia diagnosis [10]. Importantly, this relationship is fundamental for improving the quality of life for both parties, as it can positively influence the progression of cognitive function disorders and the overall well-being of people with dementia [11]. Therefore, there is a pressing need for research aimed at enhancing the relationship between informal caregivers and patients, with the goal of promoting their physical and psychological health.

Addressing Communication and Engagement in Dementia Care

In order to develop a device that improves the well-being of both caregivers and individuals with dementia, it is important to identify the specific challenges that affect their relationship and the difficulties they face in their daily lives. Communication is one of the primary reasons behind poor relationships between individuals with dementia and their caregivers [12]. Dementia patients commonly experience a decline in communication abilities, leading to apathy [13]. This decline makes it challenging for individuals living with dementia to express their emotions, resulting in reduced sharing with their informal caregivers, typically their close family members [12]. Additionally, individuals with dementia may lose interest in engaging in shared activities with their carers, further exacerbating the situation [12].

Over fifty percent of individuals living with dementia report decreased interest in activities due to diminished confidence [14]. Notably, confidence poses a significant barrier to social engagement among this population, with nearly half expressing reluctance to venture outside the home [14]. The scarcity of appealing activities to participate in may be a contributing factor to the negative attitudes of individuals towards attending social events [12]. This insufficiency can potentially reduce their inclination to partake in such activities. Thus, improving communication between individuals and their informal caregivers, as well as promoting engagement in meaningful activities, can significantly enhance the well-being of both parties.

Museums: Ideal Platforms for Dementia-Friendly Engagement

Museums can serve as valuable resources for individuals with dementia and their caregivers by providing access to dementia-friendly devices and activities that offer meaningful engagement outside the home. As public spaces, museums also play a role in promoting social connections among visitors [15]. Given their potential as platforms for public education, museums can incorporate activities related to the arts into their programming. In addition, the properties of museums lend themselves to reminiscence experiences, which can foster conversations and memory sharing among visitors [16, 17]. By offering activities that combine art, music, and reminiscence therapy, museums can offer non-pharmacological treatments and engage caregivers in the process [18]. Lastly, through hosting various events, museums can facilitate community connection and socialization for people with dementia [15]. Museums have the potential to serve as an optimal setting for strengthening the relationship between individuals with dementia and their caregivers, in addition to providing non-pharmacological interventions.

Serious Games: Enhancing Education and Social Connections in Museums

The current design aims to function as a serious game, primarily targeting the enhancement of educational and social connections. As demonstrated by empirical evidence, serious games have gained traction as a valuable instrument for augmenting visitor experiences in museums [19] [20]. Research indicates that the implementation of games in museum settings elevates visitor engagement and enriches their learning experience[20]. Furthermore, these games have been identified as facilitators of social connections among visitors, providing notable benefits for individuals with dementia and their caregivers [21]. Additionally, serious games hold promise in alleviating social anxiety, which could potentially address existing challenges in the field of psychological counselling [22]. Thus, I decided to develop an application utilizing serious game design to aid museums in improving users' social confidence.

The Royal West of England Academy: A Case Study for Dementia-Friendly Design

The Royal West of England Academy (RWA) is selected as an empirical case study to evaluate and examine the proposed design in the context of a museum setting. This venue is known for its seasonal art exhibitions and creative workshops catering to families and children. RWA situates in the city centre of Bristol in the United Kingdom. According to recent estimates [23], more than 4,000 individuals in Bristol have been diagnosed with dementia, and this number is projected to increase in the future. Previously, RWA has partnered with the Alzheimer's Society in Bristol to offer dementia-friendly activities. Given its history of supporting individuals with dementia and their loved ones through various events, the RWA was deemed an appropriate site for conducting this design endeavour. Staffs in RWA have dementia friends training [24]. RWA has instituted a monthly activity known as the "Tuesday Teatime Tour" for senior citizens. This activity consists of a complimentary guided tour of the current exhibition, followed by an afternoon tea social event. This event can be an approach to make our target users aware of the application.

Furthermore, I explored opportunities for the museum to better educate its visitors. On the one hand, it has been observed that older individuals face various challenges in leaving their residences, including adverse weather conditions and physical ailments, as reported by RWA staff. Due to the pandemic, older people have developed greater familiarity with mobile devices and the internet [25]. Consequently, online experiences and virtual activities have become increasingly prevalent in post-pandemic life [26]. RWA's practical potential and need for a dementia-friendly design make it a focal point of my design efforts.

Introducing ‘I Spy Game’: A User-Centered Application

This paper introduces the “I Spy Game”, a two-player game app adapted from the traditional children’s game, which is modified to be suitably played in the museum setting. The game requires players to work together to find a matching item based on some clues. As they play, players engage in social conversations and explain their reasoning for matching items with clues. The app has been developed through a user-centred approach, drawing upon iterative refinement using the spiral model methodology. User-centred design principles guided the app’s creation, from initial UI/UX prototypes developed in Figma to the final iteration built in Swift. One significant advantage of this digital game is its location independence, allowing players to play it in any museum or even from their homes. Given the vast number of museums in the UK [27], the “I Spy Game” has the potential to make a significant impact. By promoting social connections and strengthening familial bonds during shared activities, this game has the potential to enhance the quality of life for individuals with dementia and their loved ones.

The overarching goal of this project is to develop a serious game application that enhances the quality of life for individuals with dementia and their loved ones by improving educational and social connections. The specific objectives are:

1. Investigate the potential of museums, particularly RWA, as settings for non-medical interventions for individuals with dementia and their caregivers.
2. Employ user-centred design principles to ensure the app meets the needs of its target users, considering factors such as UI/UX design and accessibility.
3. Design and develop the “I Spy Game”, a two-player game app suitable for museum settings that promote social connections and communication between players.
4. Evaluate the effectiveness of the “I Spy Game” app in improving social confidence and museum-viewing experience for individuals with dementia and their caregivers.

Chapter 2

Background

2.1 Challenges Posed By Dementia

Prior to developing a design strategy to assist individuals with dementia, an in-depth exploration into the definition, lived experiences, and therapeutic challenges associated with dementia was undertaken. Dementia is generally characterized as a decline in cognitive function, resulting in impairment across multiple domains including cognitive thinking, language use, memory, comprehension, and judgment [28].

The cognitive and communicative issues associated with dementia often lead to negative impacts on familial relationships and broader social networks [29] (see Section 1). Individuals with dementia may experience a loss of confidence and encounter difficulties in socializing, exhibiting symptoms such as nervousness, low self-esteem, and reluctance to communicate [29]. These challenges can also produce detrimental effects on the psychological well-being of their informal carers, typically close family members or friends, often resulting in heightened levels of stress and frustration [30]. Research indicates that the well-being of both parties is closely interrelated [31].

Despite the profound changes dementia imposes on individuals' lives, there is currently no cure [32]. Thus, non-medical interventions that enhance the quality of life have garnered significant attention. Such non-pharmacological treatments can mitigate the negative side effects associated with medication and alleviate the burden on public healthcare resources [33].

2.2 Therapeutic Approaches To Dementia

In the past, dementia therapy has mainly relied on pharmacological approaches, which have received considerable scientific and medical attention [34]. However, current trends have shifted towards patient-centred research focusing on their well-being. Studies have demonstrated that individuals with dementia possess the ability to interact with others, making non-pharmacological interventions increasingly relevant. For instance, research suggests that nearly 80 percent of those diagnosed with dementia are capable of discussing their quality of life and engaging in communication [35]. Consequently, non-pharmacological interventions that promote social interaction have become increasingly viable for individuals with dementia. Among these, art and reminiscence therapies have gained particular popularity.

2.2.1 Reminiscence Therapy

Reminiscence therapy is a psychological intervention that effectively provides non-pharmacological treatment for issues encountered by older individuals, proving especially beneficial in dementia care [36]. The framework of reminiscence therapy encompasses discussing past activities, events, and experiences, often facilitated by prompts such as photographs, familiar items and music or sound recordings [37]. Reminiscence can assist individuals with dementia in reducing anxiety and depression, thereby enhancing their life satisfaction [38].

2.2.2 Art Interventions

Art interventions are highly regarded for their capacity to foster social context and stimulate creativity, which can alleviate patient suffering [39]. Art therapy, in its diverse and accessible forms, can incorporate common elements of daily life such as viewing paintings or listening to music to mitigate the symptoms of dementia [40]. For art therapy targeting dementia, researchers have advocated for the implementation of activities that promote enjoyment and happiness [41]. This underscores the significance of research efforts focused on conducting meaningful activities in public spaces such as museums, where art can serve as a potent therapeutic tool.

2.3 Museums and Dementia

Therapeutic Role of Museums

Museums are an ideal site for conducting activities that combine both art interventions and reminiscence therapy for the treatment of dementia. Given the unique settings of museums, artworks can serve as effective aids for reminiscence therapy in visitors with dementia [15].

Museums inherently possess the capability to facilitate art interventions. They can positively impact individuals with dementia by providing stimulating environments and promoting creativity [42]. In a museum setting, individuals with dementia can receive diverse sensory stimuli, which foster robust cognitive engagement across various domains, leading to intellectual stimulation[42, 43]. Consequently, art intervention in museums could potentially be efficacious in decelerating the progression of dementia.

In addition to facilitating art interventions, museums naturally encourage visitors to engage in reminiscence. The artworks can stimulate individuals with dementia and their caregivers, prompting them to reflect on their past experiences [15]. This reflective exercise can be particularly beneficial for individuals with dementia, as the process of observing and interpreting art can stimulate thought and conversation, prompting them to engage their cognitive abilities[44].

Social Role of Museums

Museums can serve as strategic venues to mitigate the social withdrawal often experienced by individuals with dementia (see Section 1). They can act as attractors, encouraging these individuals to venture outside and engage with society [15]. Museums can also facilitate opportunities for people with dementia and their informal caregivers to connect with the outside world, including museum staff, other visitors, and the societal content presented within exhibitions [45]. This can potentially alleviate their social isolation and foster community engagement. Furthermore, museums can help strengthen the bond between individuals with dementia and their informal caregivers who accompany them on these visits. This is supported by a study indicating that visitors who are accompanied tend to have a more enjoyable experience, resulting in enhanced interaction with museum exhibits [46]. Thus, museums can potentially augment the social satisfaction of individuals with dementia and their caregivers.

Challenges and Opportunities: serious game

Despite museums harbouring the potential to offer numerous benefits to people with dementia, certain obstacles prevent them from fully exploiting these institutions. Previous studies have indicated that individuals with dementia often find a lack of engaging activities suitable for them within museums, rendering the experience monotonous[47]. Additionally, they may experience information overload in large exhibitions and encounter difficulties in navigation during a tour. Digital solutions, such as innovative applications of serious games, may present a potential remedy to these issues. The “gamification” of museums, which can be defined as the application of game elements in a more serious context for purposes beyond mere entertainment [19], has been shown to augment interactions and enhance the museum experience [21]. Thus, developing a serious game that can guide them through the exhibition can make the museum tour more accessible.

2.4 Role Of Technology In Dementia Care

Touchscreen devices have become pervasive in contemporary society, and they are particularly suitable for individuals with dementia due to their intuitive and simple interaction method - tapping [48]. It has been observed that people with dementia can independently operate touchscreen devices [48]. Research indicates that a majority of individuals with dementia can utilize an iPad for entertainment, and some can operate applications such as a compass [49]. These findings suggest that developing an application for touchscreen devices as a means of improving quality of life is a viable approach for individuals with dementia.

People with dementia can obtain relaxation, engagement, and socialization through the use of digital applications [50]. Additionally, applications on tablets have been demonstrated to serve as digital therapy tools [17]. In one study, an application was designed to facilitate reminiscence exercises for individuals with dementia at home [17]. This application allowed users to upload personal mementoes, such as photos and videos, which could be collectively reviewed at a later date. Certain participants were observed to be more communicative while using this reminiscence application [17]. Consequently, mobile technology can significantly enhance the overall quality of life for individuals with mild to moderate dementia [17].

2.5 Literature Gap and Purpose of this Study

Existing research and projects have addressed the development of enjoyable game applications for public museums targeting all the visitors and mobile technologies of reminiscence therapy for people with dementia. However, given the potential for museums to enhance the experiences of individuals with dementia and their informal caregivers, there is a clear necessity for scholarly attention towards software designed to make museums more accessible and engaging for these individuals. While some apps designed for independent use by people with dementia have demonstrated positive effects on well-being [51], the needs of their informal caregivers also require consideration in the application of such technologies.

Building upon prior research and existing products, this study aims to design an app that not only incorporates effective features for aiding individuals with dementia but also introduces novel elements to facilitate their museum visits and strengthen their bonds with informal caregivers. Consequently, the application could potentially improve the well-being of both parties, with a particular focus on enhancing their social confidence.

Chapter 3

Methodology

3.1 Design Methods

The Spiral Model was utilized during the design process, with each iteration incorporating User-Centred Design (UCD) principles. Each iteration of the spiral model contains four phases, planning, risk analysis, development, and evaluation [52](see Figure 3.1).

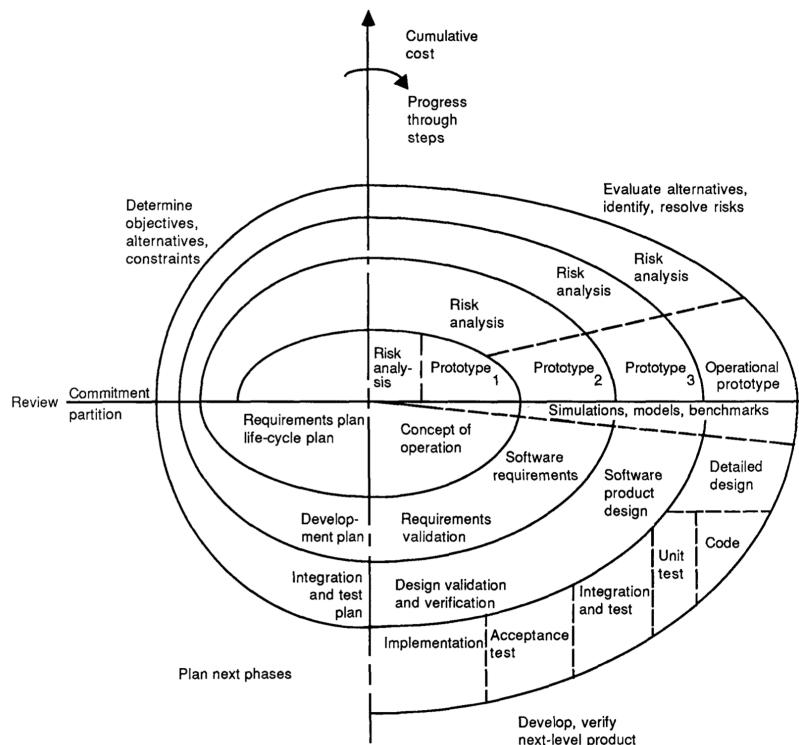


Figure 3.1: Spiral Model: Software Development Approach [1]

3.1.1 The Four Phases of Each Iteration

Plan and evaluation: User centred

The planning and evaluation stages heavily involved the primary user groups: individuals with dementia, their caregivers, and museum staff. Initially, a user story technique was employed to analyze these groups more thoroughly, focusing on expectations and requirements. This analysis encompassed their characteristics, behaviours, and the potential value of the application for them [53]. For individuals with dementia and their caregivers, the application serves as a tool to enhance their museum experience

3.1. DESIGN METHODS

and enrich their daily lives given its functionality extends beyond the museum environment. For museum staff, who often facilitate museum tours for individuals with dementia, the application is a resource to aid in the orchestration of dementia-friendly activities.

In keeping with a user-centred design approach, various user studies were conducted, including co-design workshops and interviews. The data collected from these activities were pivotal in informing the design plan and subsequent evaluation of the application. Further details on the user studies can be found in Section 3.2, 3.3, and 3.4.

Risk analysis

In risk analyses, the potential risks are classified based on their impacts and the likelihood of occurrence, which can be categorized as high, middle, and low risks. High risks are those that may significantly impede the progress and performance of a project, while middle risks may impact the project but can be remedied through appropriate efforts. Low risks refer to problems that can be ignored or resolved with minimal intervention. The development is conducted based on the user's feedback and aims to reduce the risks analysed. Simultaneously, risks are classified based on their causes, including project management risks, design risks, technology risks, and user participation risks. These risks are analyzed in each design cycle and are listed in the subsequent chapters.

Development

In each design cycle, the prototype was built or improved based on the data collected in the co-design workshop and feedback in the previous cycle's evaluation. The prototypes used in design cycles were created using Figma, a design tool that enables the implementation of multiple mobile device interface designs and facilitates rapid design modifications. During the design iterations, the Figma prototype was evaluated by participants using the HCI method known as "Wizard of Oz" (WOZ). WOZ is further introduced in the subsequent section (see 3.1.1). The final app was built upon the prototype that underwent three iterations and was tested in the final evaluation during one of the social activities at the RWA (see software development section in 3.5). The combination of User-Centred Design and the Spiral Model effectively enhanced the development of user-oriented products [54].

Method Selection: Benefits of Utilizing the Spiral Model, User-Centred Design (UCD), and Wizard of Oz (WOZ)

The Spiral Model

The Spiral Model is particularly suited to a project of substantial scale [1]. Its core principle of a four-phase iterative cycle fosters continual enhancements to the project. This aligns seamlessly with this project's user-centred structure. The structure encompasses multiple co-design workshops conducted at various intervals over a six-month period to continuously gather user data. Furthermore, this method has provided effective risk management guidance. Potential risks and challenges were analyzed in each cycle, with the evaluation phase of that cycle subsequently appraising these risks. This allowed for a timely assessment of human-induced risks. This efficient risk assessment methodology facilitated the avoidance of pitfalls such as design errors, leading to a more successful prototype. The interplay of these two phases greatly minimized the occurrence of design errors throughout the project's dynamic evolution. In summary, the Spiral Model offers an organized and efficient framework for the design process, making it well-suited to this continuously evolving project.

User-Centred Design

User-Centred Design is an efficacious approach for enhancing usability during product design [55]. This method is particularly apt for this project given the emphasis on usability and dementia-friendly features throughout the process. The fundamental premise of UCD is to incorporate end-users in design iterations, including the utilization of user study technologies such as user testing [56]. In this research, I employed techniques including user testing, user interviews, and user co-design workshops. These methodologies aided in augmenting the user-friendly characteristics of the application.

Wizard of Oz

The WOZ is a technology used to reduce costs during the early stages of design testing [57]. This technique involves a human operator simulating the responses of costly or difficult-to-develop software components during the design stage prior to the development stage. The operator remains hidden, providing the users with the illusion of interacting with a fully functional prototype. In this project, functions that required extensive coding were emulated during the evaluation phases of the design cycles. For instance, the functionality of sending a captured image from the user's input to an email address entered by users was simulated by manually sending the email during the initial stages. This method allowed for the acquisition of valuable insights regarding the desired functions through user observation before actual development, thereby reducing design and development costs.

3.1.2 Data Analysis

Data was gathered in all workshops using various methods such as observations, video, and audio recordings, as well as materials generated by the participants. After each workshop, the researchers produced field notes and observations to supplement the data collection process. The audio recordings of the workshop, which were approximately 16 hours and 30 minutes long, were uploaded to OneDrive, and Microsoft's automatic captioning was employed for initial transcriptions. However, due to the participation of multiple individuals, errors were encountered in the automated transcription process. Hence, the first author manually corrected these errors.

To derive valuable insights from the user studies, I used content analysis, a research method adept at identifying meaningful patterns within recorded communications [58]. This method is versatile, applicable to both quantitative and qualitative analysis. I utilized qualitative content analysis to gain a deeper understanding of user communication. Employing this method, I isolated samples that aligned with the defined research objectives. This approach facilitated the extraction of insightful quotes from the data amassed during the user studies, subsequently informing the design planning process.

3.1.3 An Overview Of the Three Design Cycles

To ensure the effectiveness of the design, three iterative design-prototyping cycles were conducted.

Cycle One In the first cycle, design inspiration was drawn from two pairs of participants, each consisting of an individual with dementia and their informal caregiver, during an initial co-design workshop. Based on their identified needs and requirements, the first prototype was developed. Subsequently, the prototype was evaluated by both the Alzheimer's Society coordinator and individuals with dementia and their loved ones.

Cycle Two The prototype was then refined based on the feedback received. The second prototype was assessed by the RWA coordinator, who provided feedback on the practical application of the device in museum settings, to improve its functionality.

Cycle Three After the third enhancement, the prototype was tested by people with dementia and their loved ones during the second co-design workshop. Following this, the prototype was evaluated by RWA staff members for advice on facilitating the dialogue between players. After three design iterations, the evaluated prototype can serve as the foundation for the actual software development.

3.2 The First Iteration

3.2.1 Plan

The first co-design workshop

The first co-design workshop was instrumental in developing the initial design plan. In this part, I will delve into the design ideas achieved in the first co-design workshop. The aim of this initial workshop was to collaboratively develop methods that could aid individuals with dementia in optimizing their

3.2. THE FIRST ITERATION

experience while viewing exhibitions by using technology and considering the Royal West of England Academy as an entry point. This workshop is around three “How might we” (HMW) questions related to enhancing the experience of individuals living with dementia and their loved ones in art galleries that were developed by my supervisor. The three questions are: (1) HMW facilitate social interactions between individuals with dementia and their loved ones in an art gallery setting? (2) HMW foster a sense of acknowledgement and engagement with art among individuals with dementia and their loved ones? (3) HMW encourage individuals with dementia and their loved ones to visit art galleries more frequently? The workshop aims to generate practical and effective solutions that address these important questions, ultimately enhancing the quality of life for individuals living with dementia and their caregivers.

This design process follows the principle of user-centred design, which involves the inclusion of potential users [54]. During the first co-design workshop, I discussed with participants regarding their experiences with museum viewing. Specifically, they shared what aspects of museum visiting they found most engaging, as well as what areas left them feeling unsatisfied. Additionally, we explored any barriers they encountered when participating in public social activities. Following this discussion, participants evaluated four potential design plans for an art museum, drawing from previous work conducted by my supervisors. Finally, we developed a journey map to analyze users’ potential experiences when utilizing this design.

Participants And The Site

In Fishpond, Bristol, the inaugural co-design workshop was held with the participation of two pairs of individuals living with dementia and their informal caregivers, my supervisor and two design experts recruited by my supervisor. The workshop was organized as a part of a monthly café event hosted by the Alzheimer’s Society. The two couples are members of the Society and had previously attended the same monthly café activity in Fishpond. The familiar environment facilitates the unrestricted expression of thoughts among participants. The basic situation of participants is introduced in Table 3.1. These couples have previously attended the Tuesday Teatime Tour at RWA, providing practical and valuable insights for the app’s design tailored to the RWA context.

Name	Loved One’s Name	dementia diagnosis	Age	Identity
Tina	Jack	n/a	unknown	Female
Jack	Tina	has dementia	unknown	Male
Penelope	Gabriel	n/a	76	Female: British white
Gabriel	Penelope	has dementia	71	Male: welsh, white

Table 3.1: Demographic Information Of participants In The First Co-design Workshop

The insights from the participants in the first co-design workshop

At first, the conversation started with an examination of the museum-viewing experience at RWA. Our participants conveyed that they enjoyed their visits to RWA, as they appreciate deliberating about the artwork on display and exploring the connotations of the paintings. Tina, one of the informal carers stated, *“We thoroughly enjoy discussing the artwork in the gallery and delving into the significance behind each piece. It brings us great pleasure to converse about these matters.”* Additionally, the social gathering during teatime also enticed potential visitors to visit RWA. The consensus was reached among the participants that they derived pleasure from socializing with people during the happy atmosphere of afternoon tea.

The positive feedback received from visitors about their museum-viewing experience at RWA, particularly the joy they derived from discussing the artwork and socializing during teatime, motivated me to embark on a project aimed at enhancing their interactive experience. However, it can be difficult for participants to commence a dialogue with unfamiliar individuals in the activity. Gabriel mentioned in our talk, *“As much as I like talking with people during afternoon tea, I find it somewhat uncomfortable to engage in talking with strangers. I often find myself at a loss for words and unsure of what to say.”* This suggests that the app should be designed to facilitate initial conversation and then support users’ social conversations.

Then, we had our discussion of exploring the primary challenges faced by people living with dementia and their caregivers during museum visits. The usability of applications is a crucial factor for informal

3.2. THE FIRST ITERATION

caregivers of people living with dementia. When accompanying their loved ones during museum visits, informal carers prioritize their responsibility to ensure their safety and well-being. In such a scenario, an overly complex app interface could divert their attention from their primary duty towards their loved ones and towards the technological tool instead. Tina mentioned, “*If the application isn’t easy to use, I wouldn’t be able to keep track of my surroundings and take care of my husband.*” Thus, designing a user-friendly application can enhance visitors’ sense of security during their visit. Moreover, it can be challenging for individuals with dementia to concentrate on a single art piece amidst numerous exhibitions [59]. Gabriel and Penelope expressed concern about being arduous to remain engaged while ambling through the museum.

Penelope: We love to explore the details of the paintings and dig into what the authors want to express. But just walking around is not very motivating to focus.

Gabriel: I didn’t get a chance to stop by a painting and learn it very well because there are so many things in a gallery.

This inspires me to design the app to motivate them to focus on exploring their most interesting exhibits. Also, there is a desire for the ability to socialize with others while appreciating an exhibition, which may enhance the overall enjoyment for visitors. Enhancing the social value of the museum experience can be achieved by offering shared activities and events that are not necessarily limited to the museum collection, thereby providing visitors with a shared experience [60]. Both carers expressed that they and their loved ones would be interested in joining social activities. This inspired me to design this app that can assist in their social activity in the RWA.

Finally, in addressing the needs of the older adult user group, certain design elements warrant attention. Tina remarked, “*A phone screen may be too small for optimal viewing and we prefer using a tablet instead.*” She also mentioned the app should be friendly to users with hearing loss, as hearing loss is a common condition among older adults [61]. Gabriel had a similar thought, “*I wish the app had a larger font.*” These opinions have brought to light the need to incorporate dementia-friendly concepts into the design of the mobile app.

Then, four distinct design ideas were presented to the participants, who were then asked to vote for their preferred idea. These ideas were imported from the previous studies conducted by my supervisor. Subsequently, the chosen design was then evaluated and improved according to their primary needs while visiting the museum. The four design concepts presented were as follows: (1) incidental technology in the gallery that can be activated to provide viewers with information about the art, (2) projection mapping games associated with the art, (3) online exhibitions that facilitate reminiscing about past experiences, and (4) an “I Spy” game app. Ultimately, the “I Spy” game was selected by the participants, which then allowed for a focused design effort. The “I Spy” game app is a participatory activity where users observe an exhibition and capture images of objects that pique their interest. Subsequently, users endeavour to locate another object within the exhibition that they perceive to be related to the previous finding and take another photo. It is worth mentioning that the rules of the game underwent modifications during the design process, informed by subsequent research analyses.

To build the design ideas of the first prototype, me and my participants evaluated the user journey map for potential users, focusing on the circumstances before, during, and after using the “I Spy” game app. To make the users aware of this app, one potential introduction for users would be through RWA notifications, with the game incorporated as part of the Tuesday afternoon tea activity. During the game, users are encouraged to focus on one or two exhibition pieces and continuously use their reminiscences to find related items. The approach of combining museum tours and playing a game can improve visitor engagement and promote effective learning in exhibition settings [62]. Following the game and exhibition tour, users can continue with their afternoon tea as usual and discuss their findings from the “I Spy” game with one another. They said they would want to receive the pictures of their findings by email or print them out in RWA. During the afternoon tea followed by the gallery tour, the game can serve as a conversation starter, which may aid users in enhancing their social confidence. This is mentioned by Gabriel, “*If I and the people sitting around me have common topics, I would be happier to talk with them.*” After the analysis of the activity process, we have analysed the potential long-term effects on users. Players potentially will be prompted to engage in more extensive discussions and cognitive processing during gameplay. Additionally, by sharing their game outcomes with family and friends, either by taking the print home or through email, individuals may be able to build stronger connections with others.

The Design Rationale of First Prototype (Conclusion of the first co-design workshop)

User Experience The objective of the first prototype is to create an interactive game that can be incorporated into the museum experience. By integrating games into museum visits, visitors can gain a better comprehension of the exhibits and increase their knowledge acquisition [19]. This is due to the interplay of various outcomes, including perceptual, cognitive, behavioural, and affective factors [63]. Additionally, the game allows the user to assume the role of a detective and engage with other players, including their loved ones and family members. Introducing two characters, namely a detective and an assistant, into the game is my design idea. These two game characters have the potential to enhance the user's enjoyment and engagement by fostering a sense of identification [64]. Playing games with family members or friends can facilitate social interaction and enhance cognitive function for individuals with dementia, thereby providing emotional and social support [47].

Dementia friendly User interface This design targets individuals with dementia and their caregivers, and as such, must be dementia friendly and accessible to caregivers. The following section provides a summary of the suggested attributes for user interface design that are appropriate for persons with dementia:

1. Clarity in the functions of icons and symbols used in the app is crucial for users. Therefore, icons must be readily visible, intuitive and associated with their respective functional meanings. [5].
2. To enhance user comprehension, it is recommended that instructions be presented clearly and concisely, using a step-by-step format. Recognizable virtual buttons should be utilized, accompanied by pictograms and text for additional support [5, 14].
3. Efforts should be made to design interfaces that reduce the amount of user interaction required. For example, this can be achieved by minimizing scrolling and tapping requirements [5].
4. The visual design elements that enhance user engagement and usability in mobile applications include but are not limited to: the incorporation of high-quality images and photographs, legible typography with appropriate font sizes, a serene interface and backdrop, and a suitable contrast between the text and the background [5, 14].
5. The design of auditory devices used during playing the game should consider the needs of individuals with hearing impairments. Specifically, individuals with hearing loss may prefer the use of headphones over loudspeakers due to the former's ability to reduce background noise. This is of particular importance as background noise has been found to have a detrimental effect on speech recognition and memory performance, particularly for those with lower working memory capacity [65].

3.2.2 Risk analysis after the first workshop

A risk analysis was conducted after making the design plan with the participants in the first workshop. Based on this analysis, three primary categories of risks were identified: design risks, technology risks, and user participation risks. The identified risks were then prioritized and analyzed accordingly. The following list presents the identified risks in order of priority.

1. (High risk, design risk) The interface may not be intuitive enough for people with dementia.
2. (High risk, technology risks) Applications may not work properly on all target user devices. This can be attributed to the fact that users utilize an assortment of platforms and technologies.
3. (High risk, user participation risk) In the process of co-designing with participants, their needs and expectations may be misunderstood.
4. (Middle risk, user participation risks) The number of participants is insufficient to provide a representative portrayal of individuals with dementia.
5. (Middle risk, user participation risks) It is possible that participants may not attend the feedback session as anticipated.

3.2. THE FIRST ITERATION

6. (Middle risk, technology risks) When working with programming languages, frameworks, or libraries, compatibility and performance issues can arise, potentially impeding the effective development and deployment of software systems.

3.2.3 Develop: The First Prototype

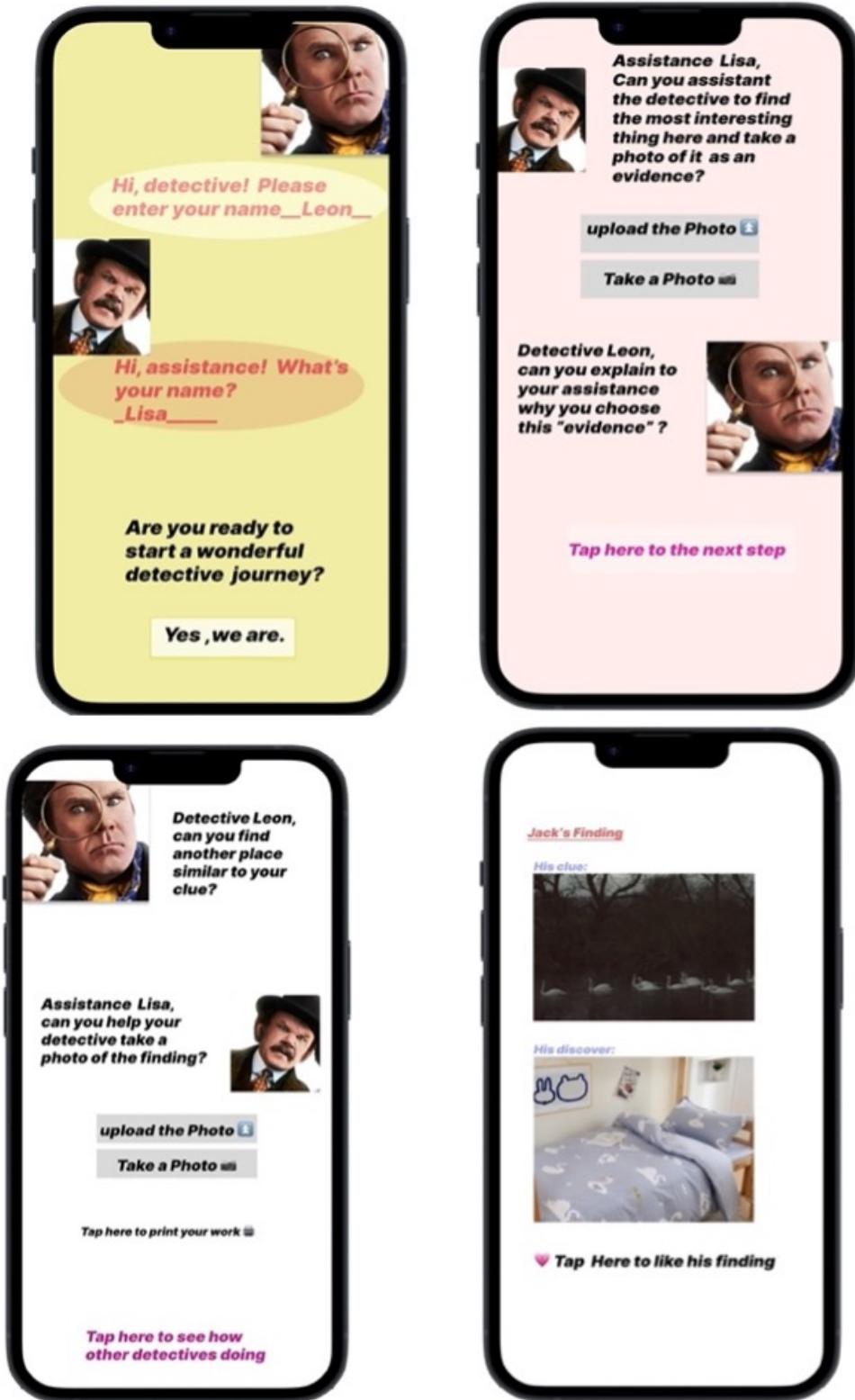


Figure 3.2: The first prototype was built based on the design rationale derived from the data gathered during the first co-design workshop (refer to Section 3.2.1). From the left to right is the first page to the last page

3.2.4 Evaluation of the first prototype

Virtual feedback session with Alzheimer's society

Four couples consisting of individuals with dementia and their loved ones participated in the meeting. In addition, Clara, the coordinator of the Alzheimer's Society in Bristol, and my supervisor also attended and provided feedback. Table 3.2 introduces the basic information about the participants. In the meeting, I introduced the concept of a dementia-friendly activity monthly held at the RWA, namely, the Tuesday afternoon tea party, to the participants. Then, I presented my first prototype and discussed its potential effects on users.

The feedback obtained from individuals with dementia and their partners indicates a favourable response. A significant number of them expressed their willingness to visit RWA and participate in Tuesday Tea Party even if they had not previously visited the museum. More specifically, they demonstrated an interest in the application as a tool for facilitating the sharing of their experiences. Joe expressed a desire to play the game with his family and friends, while Clara suggested that the game could serve as a good prompt for stimulating conversations during teatime. According to a caregiver, the discussion between “the detective” and “the assistant” has the potential to enhance the relationship between them and their loved ones, thereby strengthening their bond. Furthermore, the interactions in the game can enhance the well-being of the carers [13]. Social interactions and communications are highly valued by them [47].

Participants shared their insights and suggestions for potential future improvements. The first suggestion from participants is that the scripted dialogues between the players could be designed to create opportunities for in-depth conversations about the exhibits. One informal caregiver suggested that the question-and-answer segment between the detective and assistant characters should be customized to fit the specific theme of each gallery. According to Clara, this modification could enhance visitors' understanding and appreciation of different exhibitions.

Furthermore, with regard to the mechanics of the game, incorporating user-friendly mechanisms can assist novice players in concentrating on utilizing the game as a learning tool rather than spending time familiarizing themselves with the rules of the game. Joe suggested, “*It's better to get a picture clue first instead of scrambling to find one right away*”. Allowing detective players to find the picture “clue” by themselves after a single round of guided assistance could facilitate a more gradual and familiarized engagement with the game's process. The challenges presented to players during the early stages of a game should be designed with a lower level of difficulty, which can serve to guide players towards the later stages of the game [66].

Moreover, people may encounter situations where they are unable to physically visit a museum. An informal caregiver expressed, “The game is quite interesting, and we could even partake in it from the comfort of our home.” This underscores the necessity within the game to provide users with the ability to download the game onto their mobile devices. Such a game provides an avenue for users to connect with their loved ones and engage in a recreational activity, which can be enjoyed during family gatherings or other social events.

In addition, I initiated a vote to allow participants to choose between using a tablet or a phone. Interestingly, all couples concurred on preferring a tablet. Natalie articulated, “*A tablet can accommodate bigger font sizes,*” while Joe affirmed, “*Besides, tablets are not bulky either.*” This finding highlights the need to build the future prototype with a tablet interface view.

In conclusion, the outcome of this evaluation informed the plan for the subsequent design cycle, which is presented in Section 3.3.1.

Name	Loved One's Name	dementia diagnosis	Age	Identity
Joe	Natalie	n/a	76	Male, British, white
Natalie	Joe	has dementia	81	Female, black African
Chloe	Dave	n/a	75	female: British white
Dave	Chloe	has dementia	74	male: British white
Clara (coordinator)	n/a	n/a	30	n/a

Table 3.2: Demographic information of participants in the Virtual feedback session

3.3 The Second Iteration

3.3.1 Plan

The present prototype can be improved based on feedback received during a virtual meeting. The plan for enhancement includes:

1. Continuous improvement of the design with the aim of enhancing the museum viewing experience.
2. Customization of the question-and-answer segment between the detective and assistant characters to align with gallery themes.
3. Improvements of the mechanisms to be more user-friendly and assist novice players. Adding the function of letting users choose to use the given clue or find the clue by themselves.
4. Develop the prototype to allow for user interaction.
5. To ensure the potential for future reminiscence, an email function has been incorporated into the application, enabling users to maintain multiple records of the game.
6. Change the interface view of the prototype from a phone to a tablet.

3.3.2 Risk analysis

In the virtual meeting, positive feedback was obtained, which effectively resolved the problem of potentially misunderstanding users' needs and expectations. Nonetheless, the feedback received regarding the addition of a new feature to enable users to select clues indicated that it could increase the complexity of the application, thereby posing potential technical and design risks. The risks analysed in the second iteration contain:

1. (Middle risk, design risk) The more complex interface may add a sense of confusion for the users.
2. (Middle risk, technology risks) The introduction of the new adding function has led to a more complex code architecture, resulting in heightened difficulty in building the application. This increase in complexity also raises the possibility of encountering issues related to frameworks, libraries, compatibility, and performance.

The following risks have persisted from the previous iteration.

3. (High risk, user participation risk) In the process of co-designing with participants, their needs and expectations may be misunderstood.
4. (Middle risk, user participation risks) The number of participants is insufficient to provide a representative portrayal of individuals with dementia.
5. (Middle risk, user participation risks) It is possible that participants may not attend the feedback session as anticipated.

3.3.3 Develop: the second prototype

Development 1. As shown in figure 3.3, in order to enhance the user experience of playing the game, the view has been modified to accommodate tablet devices. Additionally, onboarding pages have been incorporated to assist users in preparing for the game.

Development 2. (figure 3.4) The Figma prototype has been enhanced with the addition of interactive features, which are activated through buttons that enable users to navigate to the next page by tapping or dragging. The buttons are represented by intuitive icons, such as a hand tap, to enhance user understanding and ease of use. Moreover, each page is equipped with a "back" button for easy navigation to the previous page.

3.3. THE SECOND ITERATION



Figure 3.3: Development 1. Change Of The App View

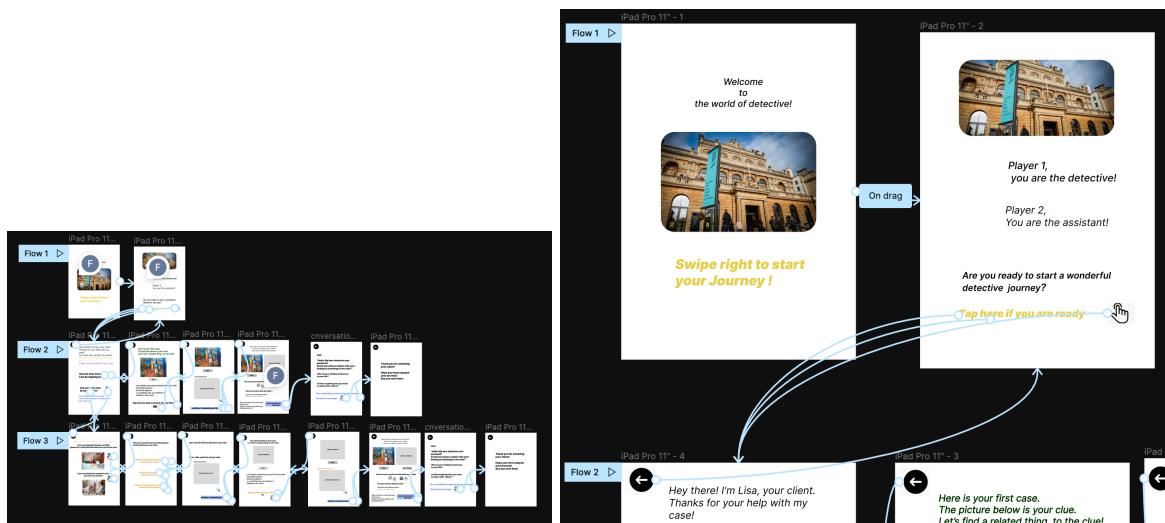


Figure 3.4: Development 2. Interaction Flows And Navigation Buttons

Development 3. (figure 3.5) Incorporated into the application was an email feature that enables users to enter their email addresses. Upon submission, the app automatically transmits their findings and corresponding clues to the provided email address. The email function's efficacy will be assessed through the method of "Wizard of Oz" during the prototype evaluation phase and subsequently through comprehensive testing during the final evaluation once the application is built. (The concept of Wizard of Oz refers to Section 3.1.1.)

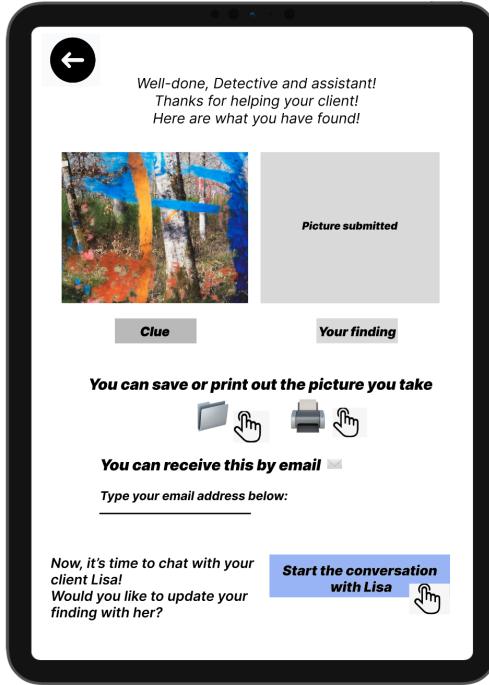


Figure 3.5: Development 3. Email function

Development 4. (figure 3.6) This prototype introduces a new page that provides users with two options for finding a matching object: (1) using the app's provided clue or (2) finding the clue for later use. The latter option aims to reduce a step and make the game easier to play. Users have the option to start with the simpler game mode, allowing them to familiarize themselves with the game mechanics.

Development 5. In contrast to the previous prototype, which provided users with only one hint - to find the most interesting thing - the current iteration offers an enhanced feature. Specifically, it includes an additional page where users can choose from three hints, selecting the one most applicable to their current location or exhibition theme (shown in figure 3.7). This implementation responds to the user expectations elucidated in the preceding evaluation – to stimulate more in-depth discussions relevant to the gallery's theme.

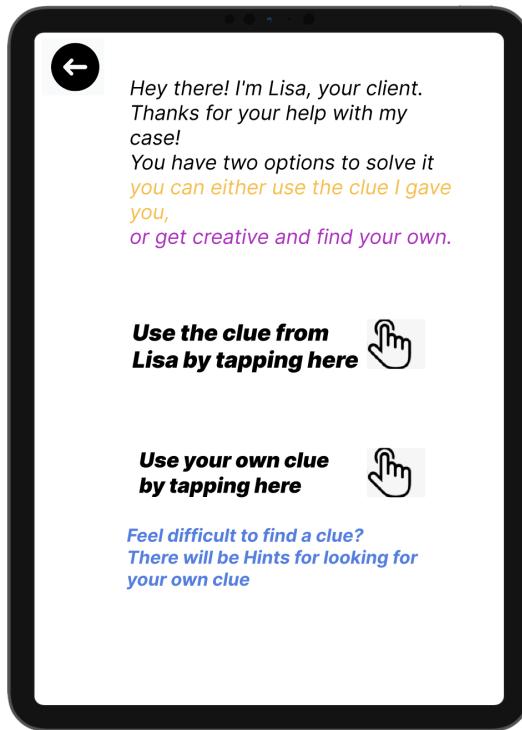


Figure 3.6: Development 4. A new feature of choosing clues

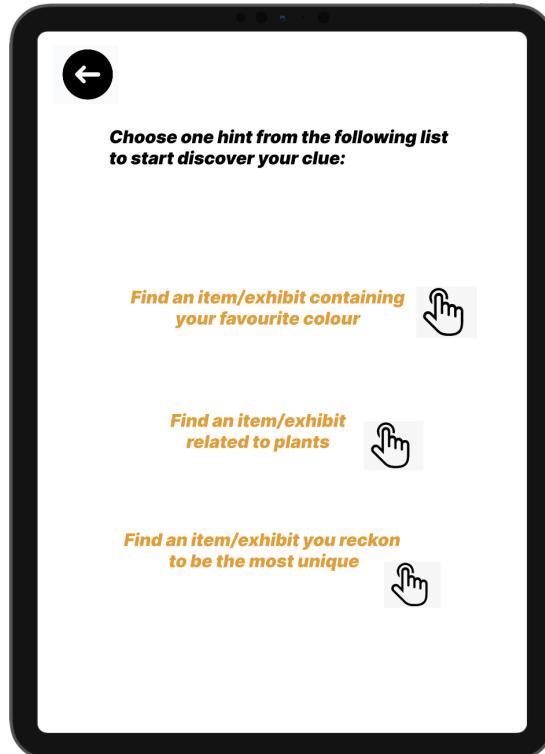


Figure 3.7: Development 5. A new page containing more hints for finding clues than the previous prototype

3.3.4 Evaluation: Feedback interview with RWA Program Coordinator

During the meeting with Helen, the head of learning and engagement at RWA, I presented a design

3.3. THE SECOND ITERATION

idea for a game prototype, along with feedback received from the Alzheimer’s Society. Our discussion with Helen centred around potential improvements to game mechanics, benefits users could derive from the game, potential technical support from RWA, and how the game could enhance the Teatime Tuesday Tour activity at RWA.

Feasibility of Implementation

We examined the suitability of two approaches for generating the “clue” for the “detective”. The first involves user-generated clues, while the second entails the provision of clues by the game database. In the initial prototype development, players were tasked with identifying the most captivating object in the exhibition as the designated “clue”. During the virtual meeting, participants proposed the possibility of customizing this feature to suit the unique attributes of each exhibition. I presented this suggestion to Helen, who possesses comprehensive knowledge of the various exhibition types hosted by RWA. Helen suggested, *“if we could, between us kind of contrived some stock questions that you could draw from that, that then perhaps you only have to tweak a couple of words to change it [...] then the staff] could have a list that you could do some mix and match perhaps. So, that would certainly save us time.”* This suggestion can assist the staff at RWA in easily setting appropriate questions that match the content of various exhibitions. Instead of designing new questions every time the exhibition changes and subsequently editing the app’s code, this can aid staff and future app developers in reducing their workload. Helen alluded to the program team within RWA who are available to aid in scrutinizing this list of questions. After Helen’s recommendation, I intend to convene a meeting with the program team to solicit their insights in formulating the questions. I plan to introduce a new page within the application that incorporates the aforementioned function. A function will be designed with features aimed at assisting staff in generating questions with minimal effort. For example, this function entails the utilization of two lists of adjectives and nouns, from which staff members can selectively choose, providing them with the ability to mix and match as desired.

Upon analysing the clues found by users, we deliberated on another way of providing users with the clue directly. I consulted with Helen regarding the feasibility of giving users with a hybrid of textual words describing exhibits and pictures of exhibits. Helen shared her agreement on using words, *“Because some people’s brains actually are wired to register a word more so than the image, aren’t they? I know my mum will be like that [...] words would be what she would look for and latch onto [...] some people might respond, to a word better than a picture. Cuz sometimes you can see a picture and think, I know I’m meant to make a connection with that, but I’ve lost that as well somewhere.”* The decision of using words or images can be controversial. Generally, individuals with dementia find it easier to comprehend images than words due to the fundamental cognitive differences between processing visual versus textual stimuli [67]. Nonetheless, the results of the study conducted by Matthew et al. [67] and Helen’s observations show that a minority of individuals possess better cognitive abilities for comprehending textual information rather than visual ones. Thus, I intend to use different ways of displaying clues in the two game modes for obtaining them.

Potential advantages for users

We assess the app’s potential impact on users’ post-museum viewing experiences. One of the app’s features allows users to save their game results, which include the “clue” and “finding” as a keepsake by either printing them out or sending them via email. Helen asserts that *“You are at home, and you can still see the pictures you took or something that’s like really, like you said, really reinforcing the memory, isn’t it?”* Participants can review their achievements at any time after completing the activity, whether they look through the photo album in their emails or share the printing at a family gathering. This can serve as a prompt for them to discuss the experience days or weeks later and help them recall their memories. Reminiscence therapy has been recognized as a viable non-pharmacological intervention for individuals with dementia, which has shown efficacy in addressing the condition [36]. This therapeutic approach has been observed to impart emotional and social advantages to those living with dementia [36].

The exhibition tour included in the Tuesday teatime activity may remain the same, even after several rounds of the activity. Helen suggested: *“Perhaps if you were going to come to the two teatime tours that are during the photo exhibition, the one time you have a good look around and have the tea and then maybe the second time, what, what more can I get out of it this time? I mean the person living with*

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dementia may or may not remember having done it and perhaps if they've got some a trigger from it, that might bring back some memories." This consistency allows return visitors to view the same gallery, potentially eliciting recollections from their previous visit, thus providing an effective opportunity for reminiscence therapy.

Enhancing Teatime Tuesday Tour through Game Improvements

During social activities, individuals often struggle to break out of their comfort zone when interacting with a group containing strangers.^[68] Although this tendency is a natural phenomenon, social activities designed to promote engagement should strive to avoid it. To enable a comprehensive analysis of the social dynamics during the Tuesday Teatime Event, we were provided with Helen's observations of visitors' interactions from previous events organized by her.

Helen: as people come in, they sort of go to wherever they go and just sit there. They don't get up to move again. So, it's not social in that you think, oh, I'll go and chat to Elena, I'll go and chat to Bob now. [...] You just stay sitting who you are with. It might be disruptive, but it could be nice to say, now you have had a cup of tea and a piece of cake. Who would like to move tables or who would like to try, I did notice the people from [the care home], they all came together. So, it was five people living with dementia and two carers and a driver. They all sat at one table. And I couldn't help thinking, oh, I sort of wish you'd spread out. And then you could talk to other people. And I can't enforce that obviously. But it could be fun if you are mixing it up because it's game and saying, hey, who would like to play with someone they've not talked to today?

In general, people tend to struggle with stepping beyond their usual patterns of communication when interacting with others. Nevertheless, the anxiety that accompanies talking to unfamiliar individuals is usually overstated and can actually result in positive results. ^[68] Introducing the I Spy Game in the RWA could provide a favourable experience of engaging with strangers, potentially encouraging repeat visitors to initiate future interactions with strangers and improve their social confidence ^[68]. At the tea party that follows a tour of the RWA, attendees commonly gathered in a casual social setting to partake in tea and cakes. The topics of conversation were not always related to the art exhibition that was just viewed. While social interaction may help visitors to develop their confidence, the gallery itself offers educational benefits that are worth exploring. After using the I Spy Game app, individuals can share their experiences exploring the exhibition during teatime. Helen provided an example of how this might work.

Helen: It's nice if you are playing a game and comparing things or just have a laugh I suppose together, isn't it? You probably won't be poking fun at somebody, but you might be thinking like, the red thing that's not red or, you know, Cuz they might say, that looks orange to me. Even so, you are still engaging, aren't you?

This game can promote visitor engagement in tea parties and aid in achieving the educational goals of the museum. Moreover, playing a game that involves locating and observing items within the exhibition encourages visitors to pay greater attention and appreciate museum exhibits during their tour. This may lead them to immerse themselves in art, which has been shown to have benefits in easing symptoms of dementia ^[15].

Possible support from RWA

One of the significant objectives of this meeting is to seek Helen's consultation regarding the viability of supporting the usage of the app for the museum's activities. A fundamental requirement for availing of this application's assistance includes the possession of a mobile device and a printer. As per Helen's response, the museum is presently equipped with two iPads and can procure additional ones in the future. Ordinarily, visitors can borrow the necessary tools from the office located behind the reception desk. The museum already possesses an instant printer that can receive data via SD card. These are promising developments, as all the devices required at present can be adequately supported by RWA.

Conclusion of meeting with the coordinator at RWA

Receiving feedback from the coordinator responsible for organizing the target activity and site of the design, who has participated in the activity multiple times, can be a beneficial resource. Positive

feedback can provide me with valuable insights into the benefits an app can offer, identifying areas where users could benefit, and informing potential feature additions for future development. The utilization of the app may offer a good opportunity to provide memory-enhancing exercises to individuals living with dementia. The application prompts the user to retain a piece of information and subsequently identify its related counterpart. Furthermore, the application provides the user with the chance to save the activity as a memento for future sharing, which helps in strengthening memory retention. This application can enhance the museum visiting experience by bolstering users' motivation to engage with artworks and facilitating social interactions. Users may experience increased confidence when conversing with unfamiliar individuals, leading to an overall more positive social experience.

In addition, Helen offers practical suggestions for improving the app, which enhances its accessibility. The available hints or questions for discovering a "clue" within the app were limited and may not engage the players. Incorporating a diverse range of questions that are both relevant and intriguing to the content of the exhibition could provide a more compelling experience. Helen proposed that a wider range of questions can be generated by utilizing the function that allows for the combination and arrangement of words. Additionally, the app can enhance the museum viewing experience by providing added motivation for observing artworks and fostering social interaction among users. Finally, the technology risk of device incompatibility of the app has been resolved with the confirmation received from Helen, who provided information regarding the provision of iPads and printers by RWA.

3.4 The Third Iteration

Following two iterative cycles of enhancement, the prototype was endowed with essential functionalities and subsequently appraised by representatives from two distinct user groups: museum personnel, and individuals with dementia alongside their informal caregivers. Towards the conclusion of this development cycle, the ultimate objective was to conduct a comprehensive assessment of the prototype. The purpose of this assessment is to evaluate the feasibility of the prototype as a foundational model for the development of an actual Human-Computer Interaction application.

3.4.1 Plan

1. Ensure that the application is versatile enough to be utilized in diverse exhibition themes and beyond the confines of the museum.
2. Organize a subsequent co-design workshop with individuals living with dementia and informal caregivers to assess the final iteration of the prototype.
3. Convene a meeting with additional members of the RWA team to deliberate on the most effective arrangement of clues and hints appropriate for a museum environment.

3.4.2 Risks and challenges

1. (High risk, user participation risks) The possibility of participant non-attendance at the prototype's final evaluation session may lead to an unanticipated delay in transitioning the prototype to the app's actual development phase.
2. (Middle risk, user participation risks) The number of participants is insufficient to provide a representative portrayal of individuals with dementia.
3. (Middle risk, user participation risks) The co-design workshop is subject to time limitations. Consequently, there is a risk that adequate time may not be available to sufficiently engage with and receive input from all participants.
4. (Middle risk, user participation risks) The app's evaluation is not conducted in the authentic setting that it primarily targets, which poses a noteworthy risk to its efficacy.
5. (Middle risk, design risk) The current user interface is deemed unsuitable for the intended user demographic.

The following are the remainder risks:

6. (Middle risk, design risk) The more complex interface may add a sense of confusion for the users.

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7. (Middle risk, technology risks) The introduction of the new adding function has led to a more complex code architecture, resulting in heightened difficulty in building the application. This increase in complexity also raises the possibility of encountering issues related to frameworks, libraries, compatibility, and performance.
8. (Middle risk, design risk) The design fails to align with the users' anticipated design features.

3.4.3 Develop: the third prototype

This iteration of the prototype incorporates a new feature: a page dedicated to generating a wide range of potential clues. Within this page, users can select a phrase from two distinct columns. This design aims to eliminate the need for staff members to regularly adjust the clues, thus allowing players to easily select different options at their discretion. The thematic content of these phrases is scheduled to be discussed during a meeting with RWA staff members after this iteration cycle.

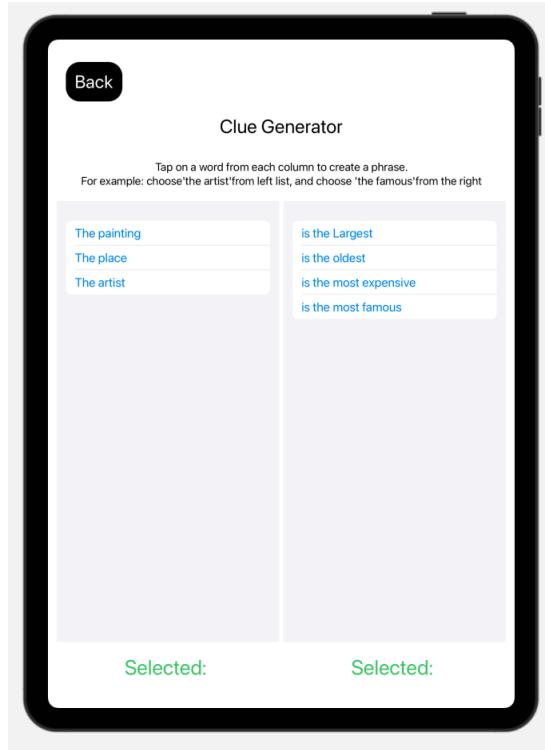


Figure 3.8: Various clues can be produced by mixing and matching phrases.

3.4.4 Evaluation: The second co-design workshop

The second co-design workshop

The second co-design workshop took place at the Vassal community centre located in Fishponds. The participants comprised two couples, each consisting of an individual with dementia and their respective spouse, a volunteer, and myself, alongside my supervisor (Table 3.3). The workshop aimed to evaluate the usability of the current prototype's interaction, with a particular emphasis on its intuitiveness for individuals with dementia and their caregivers. Based on their feedback, further iterations were made to ensure that the prototype is adequately refined before moving forward to the coding phase.

The meeting began with conducting a trial of the prototype with individuals diagnosed with dementia and their caregivers. The primary objective was to identify any potential issues in the prototype's functionality during real-world usage. If an issue arose during the testing phase, measures were taken to rectify it by promptly soliciting feedback from the participants. Additionally, the participants were asked

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Name	Loved One's Name	dementia diagnosis	Age	Identity
Joe	Natalie	n/a	76	Male, British, white
Natalie	Joe	has dementia	81	Female, black African
Penelope	Gabriel	n/a	76	Female: British white
Gabriel	Penelope	has dementia	71	Male: welsh, white
Monica (Volunteer)	n/a	n/a	n/a	n/a

Table 3.3: Demographic information of participants in the second co-design workshop

to provide their recommendations on how the design could be improved, as well as their expectations for the final product. Before the testing, participants were persuaded to disregard any environmental discrepancies between their current meeting space and a museum. Likewise, I apprised the participants that the ultimate version of the application will be accessible on an iPad, as opposed to a laptop. Meanwhile, I employed the Wizard of Oz technique to simulate the functionalities of uploading and emailing photos within the context of my study on human-computer interaction. In summary, the testing provided valuable insights into the prototype’s performance, simulating crucial functionalities. The subsequent section will delve into the specific issues that emerged during this evaluation, shedding light on potential improvements for the final iteration of the application.

During the testing process, I observed that the interactions were not adequately signposted and did not offer a sufficient level of comprehensibility. Since the prototype was created using Figma, it is currently limited to being accessible only on a laptop. After launching the application, I presented the onboarding page, which will serve as the initial view when the user interacts with it at the museum. I proceeded to ask the participants to instruct me on which areas of the laptop interface to interact with, which I would then perform on their behalf. Prior to doing so, I confirmed their understanding that the action of clicking on the prototype is analogous to finger tapping in the final application. The two participants who were living with dementia exhibited confusion when attempting to initiate the game, as they were unsure of where to click. Upon being directed towards a hand icon, they began to show some degree of agreement that this icon could serve as a navigational tool for progressing to subsequent pages. Through their reaction, I came to the realization that the design of interaction buttons ought to be more prominent and the functionality of the buttons should be emphasized. Based on my observations, the informal caregivers were able to comprehend the icons displayed on the application.

Joe: “What picture would you, where do you think you would click on that to make it change?” Natalie: “I’m not sure.”

Upon observing this issue, we expeditiously initiated a discussion to determine potential solutions for improvement. Joe: “A ‘start’ can be clearer, or an arrow.” The participants’ feedback was instrumental in inspiring the improvement of the navigation experience on the interface. More specifically, a concise phrase was incorporated in close proximity to the button to offer contextual guidance.

We conducted an evaluation of the primary gameplay mechanic, which involves the task of identifying a pertinent item based on a given clue. Observations from the testing process indicate that the game’s functionalities can potentially enhance users’ social confidence, foster greater engagement among co-players, and improve the players’ sense of connectedness. This transformation in attitude is exemplified by Natalie’s shift in behaviour during the study. Prior to engaging with the game page, while testing the onboarding phase, Natalie exhibited shyness and even displayed a reluctance to speak in front of others when prompted with questions, asking, “*Why do you have to point it to me?*”. However, as the process unfolded, she gradually began to open up to the participants. Upon viewing an image of a clue and being asked to find a matching item, Natalie quickly expressed her desire to select a blue board. Subsequently, she demonstrated enthusiasm in sharing her personal experiences, remarking, “What does that remind me of my life? Oh, teaching,” and proceeded to recount stories of her time as a teacher. This outcome aligns with the application’s objective to assist individuals like Natalie in unfamiliar social situations, facilitating conversation and enabling them to express their thoughts freely.

Apart from enhancing social confidence, which is one of the primary objectives of the application, our participants also demonstrated the app’s ability to foster the relationship between two players. When Natalie was prompted to elucidate the teaching narrative behind her discovery related to a specific clue, her spouse Joe eagerly proclaimed to others, “I knew you were going to say that.” This interaction

3.4. THE THIRD ITERATION

evoked laughter among fellow participants, who remarked that the couple appeared to know each other exceptionally well. Similar interactions, as observed between Natalie and Joe, can be experienced by other couples using the app, thereby strengthening their relationships. Additionally, positive feedback from others can further bolster their bond [69]. Whether engaging with the game at home or in a museum, they may potentially receive additional commentary from external sources, such as other family members, visitors and staff in the museum. Social support for their relationship could reinforce their mutual feelings of approval and commitment, ultimately solidifying the relationship [70].

The feature enabling players to save their in-game discoveries through email or printing was well-received by the participants. Moreover, the evaluation session validated that the risk of not meeting the expectations of the target users has been successfully reduced. Once participants captured a photo of their findings, the app permitted them to save an integrated view of the clue and the discovery by printing it or receiving a copy via email as a backup. Participants expressed a preference for this design over solely saving the information on their handheld devices. Natalie stated, “*We can’t rely on the computers*”. Joe concurred, adding, “*If you want a copy for future use, then our copy is like receiving delightful greetings, similar to emailed Christmas cards. I believe many people would prefer to have a tangible card they can preserve*”. While younger generations increasingly prefer digital information, older individuals tend to gravitate towards paper formats and in-person interactions, which provide them with a sense of comfort [71]. Furthermore, the email feature enables users to input their email addresses and transmit the combined view to themselves, allowing them to print their work at their convenience and share their museum experiences after leaving the museum. This feature is anticipated to help users retain memories to share with other family members, including those who did not accompany them to the museum, thereby fostering stronger connections between people with dementia and their families.

We also examined the potential of this game to enhance user experience during museum visits. Specifically, we explored how the game could impact users’ emotional states while engaging with it. In the context of setting picture clues within the picture clue mode, Joe proposed, “*One idea I would suggest is selecting images that you believe will elicit a reaction of some sort. For instance, these could be images that evoke memories of the past or provoke emotions, whether positive or negative.*”. Visual stimuli in pictures have the potential to elicit emotional responses in viewers [72]. For instance, nature imagery has been shown to have a positive influence on users’ moods [73]. Similarly, images of food may also contribute to enhancing mood by acting as positive stimuli [74]. Incorporating the feedback received during the first cycle evaluation, the clues were refined to better align with the museum’s theme. The selected images for this application should provide positive indications of users’ moods and maintain relevance to the museum context.

Regrettably, the co-design workshop faced time constraints. The newly developed feature, which was advised by the feedback from museum staff members during the prior design cycle’s evaluation, has not been assessed in this user study. As a result, this aspect is scheduled for investigation in the final evaluation.

The conclusion of the second co-design workshop

1. The participants recommended enhancing the user interface to make it more suitable for individuals with dementia. The evaluation results revealed that the implemented design changes did not effectively mitigate the risk of an interface that is unsuitable for the targeted user group (see risk analysis 3.4.2).
2. The participants expressed a preference for printing documents rather than saving them on mobile devices. This finding suggests that the issue of non-alignment with users’ anticipated design preferences has been successfully addressed (see 3.4.2).
3. The responses from participants in the workshop indicated that the application has the potential to improve both the relationships among players and their social confidence. Nevertheless, the risk of an insufficient number of participants to provide robust evidence for the group they belong to persists (see 3.4.2).
4. The images for the clue in this application should provide positive indications of users’ moods and related to the museum context.

3.4.5 A Meeting with RWA Staff Members to Discuss Clue Generation

The objective of scheduling this meeting is to discuss phrasing in clue generators. This is because their experience of observing dialogues among individuals at exhibitions, as well as the questions frequently posed by visitors, can assist in identifying engaging topics for individuals with dementia. This will enable the clue generator to construct more appealing clues. Prior to the meeting, my supervisor and I attended a Tuesday teatime party, which is a public event for people with dementia and the primary context in which our app aims to provide assistance. The final evaluation of the app will be conducted during one of these future events.

Topics are particularly relevant to individuals with dementia and older adults and are intended for incorporation into the game setting, thereby increasing user engagement. Staff members who have guided individuals with dementia through exhibitions were interviewed to gather insights into the questions commonly posed by this population during these events. The frequent topics identified include artists, price, and artwork dimensions. In addition to drawing upon the experiences of staff members who have interacted extensively with individuals with dementia, researchers have also suggested that topics involving children can be popular among this demographic [75]. Furthermore, storytelling is a well-regarded and engaging social activity for individuals with dementia, and incorporating questions that encourage storytelling can contribute to their enjoyment [76]. Hints related to childhood, marriage, and daily life can serve as stimuli to facilitate story sharing and conversation with others, which, in turn, can enhance user interaction [76]. The enhancements of phrase configurations in museums and other settings have been further developed, as depicted in Figure 3.9 and Figure 3.10.

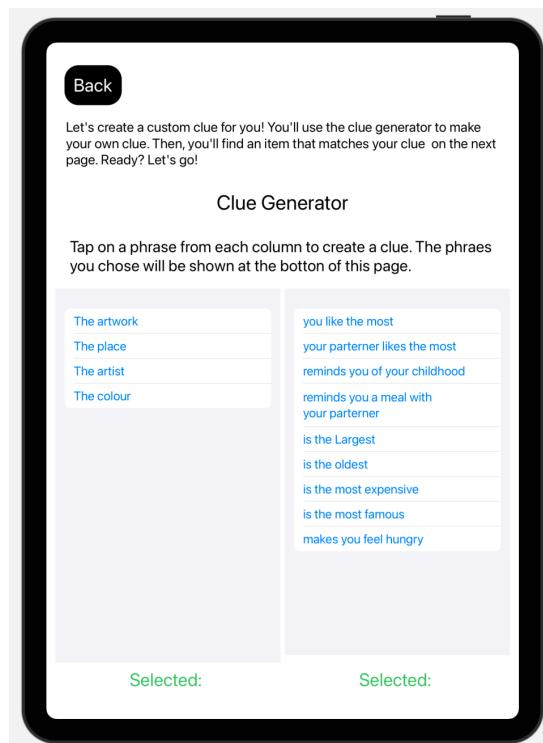


Figure 3.9: Clue generator for using in a museum setting.

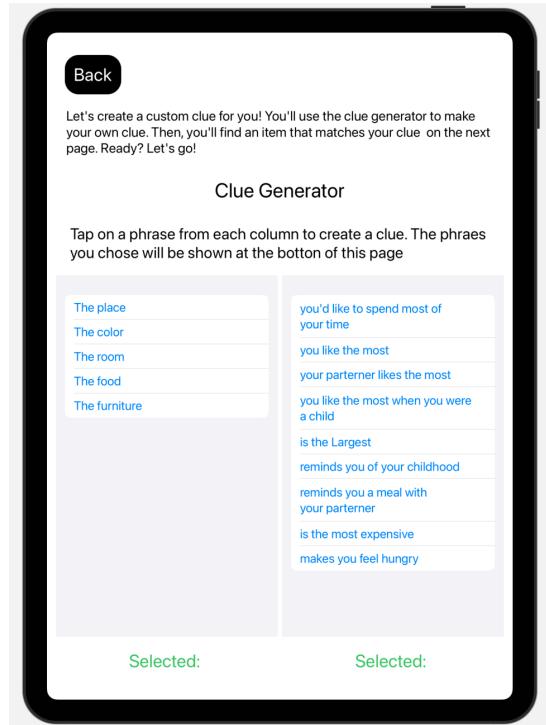


Figure 3.10: Clue generator for using at other places, such as at home.

3.5 Software Development

3.5.1 System for developing:

Following three iterative cycles and refinements to the prototype, an iOS application was developed, adhering to the design ideas established during the prototyping phase. The decision to focus on iOS development was further reinforced by the information provided by the RWA museum coordinator, who indicated that iPads would be available for visitors' use. This choice proved advantageous for several other reasons, including the secure data system of iOS, which is particularly beneficial for public-use devices in museums, as it may securely store data for other purposes [77]. Additionally, the iOS platform offers a more expedited timeline for application release in comparison to alternative systems, thereby facilitating earlier access for future researchers and users. This section will provide an overview of the key content developed during the application construction process.

3.5.2 Architecture:

The development of this app adhered to the lightweight Model-View-Controller (MVC) architectural pattern (Figure 3.11). Given the time constraints of the development cycle and the modest scale of the application, the MVC approach is more suitable than the Model-View-ViewModel (MVVM) paradigm. In implementing the MVC pattern, the concepts of view and controller sessions are adapted. The controllers are responsible for handling user input and updating the view, while the views are dedicated to displaying the user interfaces. As the interactions between these two components are minimal, the development of this application emphasizes bidirectional communication between "views" and "controllers", instead of using the "model" as an intermediary. Besides, certain files containing practical methodologies are stored in a distinct "helper" file, ensuring an organized and streamlined codebase while preventing code duplication. The clear separation of components (views, controllers, and helpers) facilitates a more organized and efficient management of the codebase.

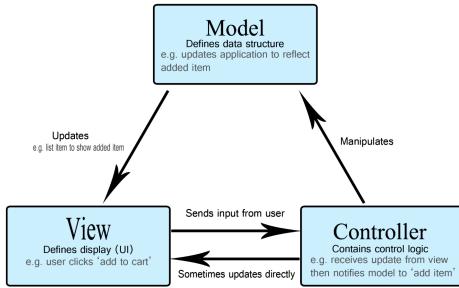


Figure 3.11: Model-View-Controller architecture pattern [2]

The First Iteration

Camera and photo library functions (Page1View.swift; TakePhoto3.swift in figure 3.13, 3.14)

Two iterations of the codebase were developed, with the initial version illustrated in figure 3.12 - 3.15. In the first iteration, I utilized logically duplicated code to implement photo capture, uploading, sending, and printing functionalities for both modes of acquiring the “Clue.” In both game modes, the camera and choosing from the library utilize a reusable helper struct named “ImagePicker”, which conforms to the “UIViewControllerRepresentable” protocol. The “ImagePicker” structure integrates the “UIImagePickerController” built-in view controller from UIKit into a SwiftUI view. Upon capturing an image, the user can pass it to a closure named “onImagePicked,” and the view controller will subsequently dismiss it. I used two sheets for the camera and photo library to reference this struct, respectively. When the user activates either button for those two functions, the corresponding “isPresented” state variable is set to true to display the corresponding sheet.

Email and print functions (Page3View.swift; EmailPrint5.swift in figure 3.13, 3.14)

These two functions aim to help users save a combined view of entered players’ names, the “clue” and their “finding”, by printing or emailing to an entered email address, or both. This view and controller page uses several helpers: CombinedView.swift, RenderImage.swift and ImageControllers.swift. The data of the picture that users took are passed from the “ImagePicker” struct. The CombinedView struct is for creating a view containing the captured text from the text field of the user’s entered name, the clue and the pictures. In RenderImage.swift, I defined a function called renderViewToImage that can take a SwiftUI view as input to return an UIImage (an image class in iOS). This code implements an error handling mechanism to display error messages when rendering fails. If the returned image has a width or height of 0, the function prints a message indicating that the view failed to be rendered as an image. In ImageControllers.swift, I used “UIPrintInteractionController” and “MFMailComposeViewController” two built-in classes for implementing print and email functionality in iOS applications. The function allows the image to resize to an A4 size sheet before printing. When a user taps either the email or print button, the clue and captured image arguments are initially combined in a new view. They are subsequently rendered to an image and then either emailed or printed, as appropriate.

Utilizing replicated logic and functions for development is suboptimal, resulting in a redundant and repetitive codebase that is challenging to maintain. Although such an approach may appear to reduce the workload at the architectural or logical layer, it inadvertently increases the burden during practical implementation. For instance, when editing or debugging the code, modifications must be made to both instances of the duplicated codebase. Furthermore, this architecture diminishes the codebase’s readability, necessitating twice the time for comprehension. Consequently, the codebase was refined to produce a second version that eliminates code repetition.

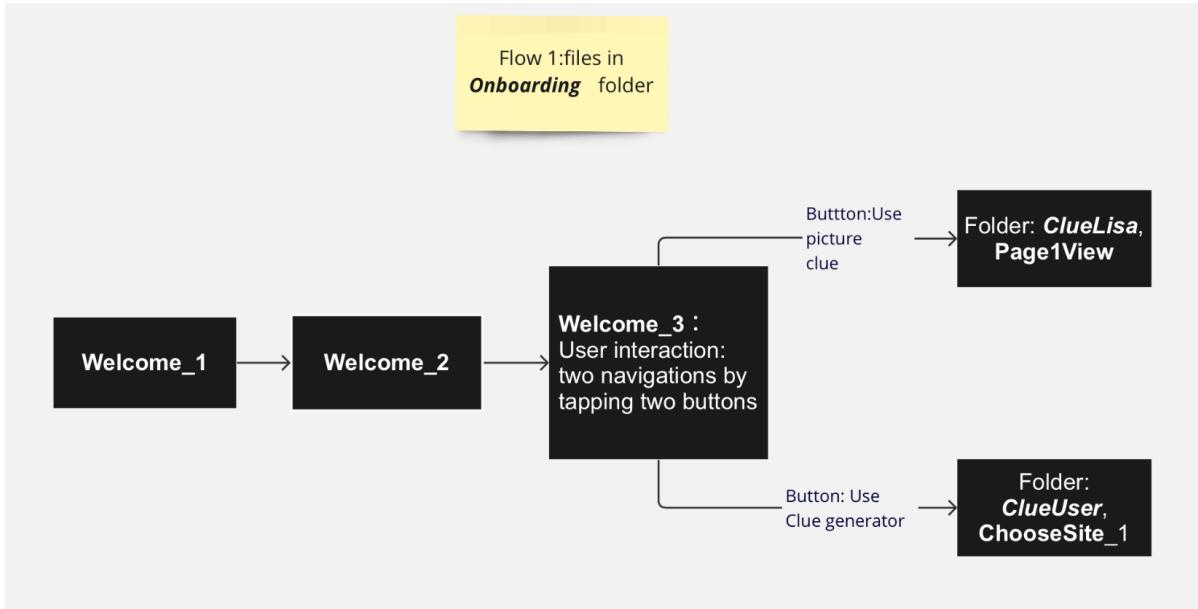


Figure 3.12: Architecture of the first iteration, flow 1

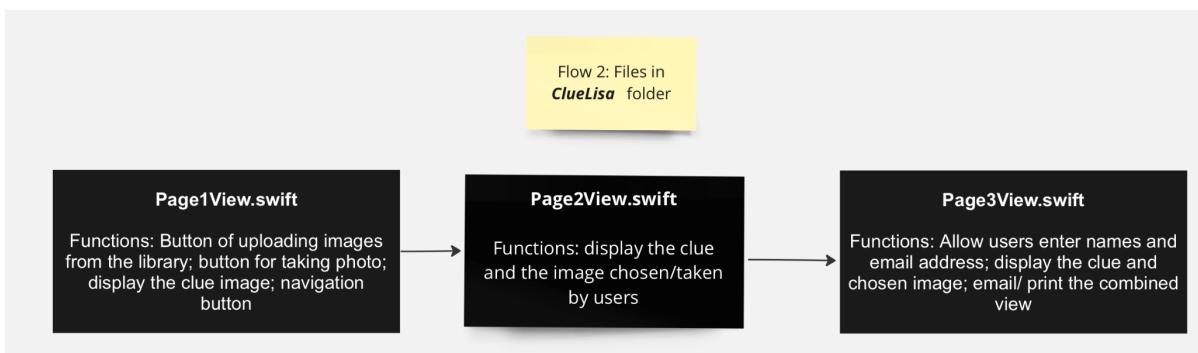


Figure 3.13: Architecture of the first iteration, flow 2

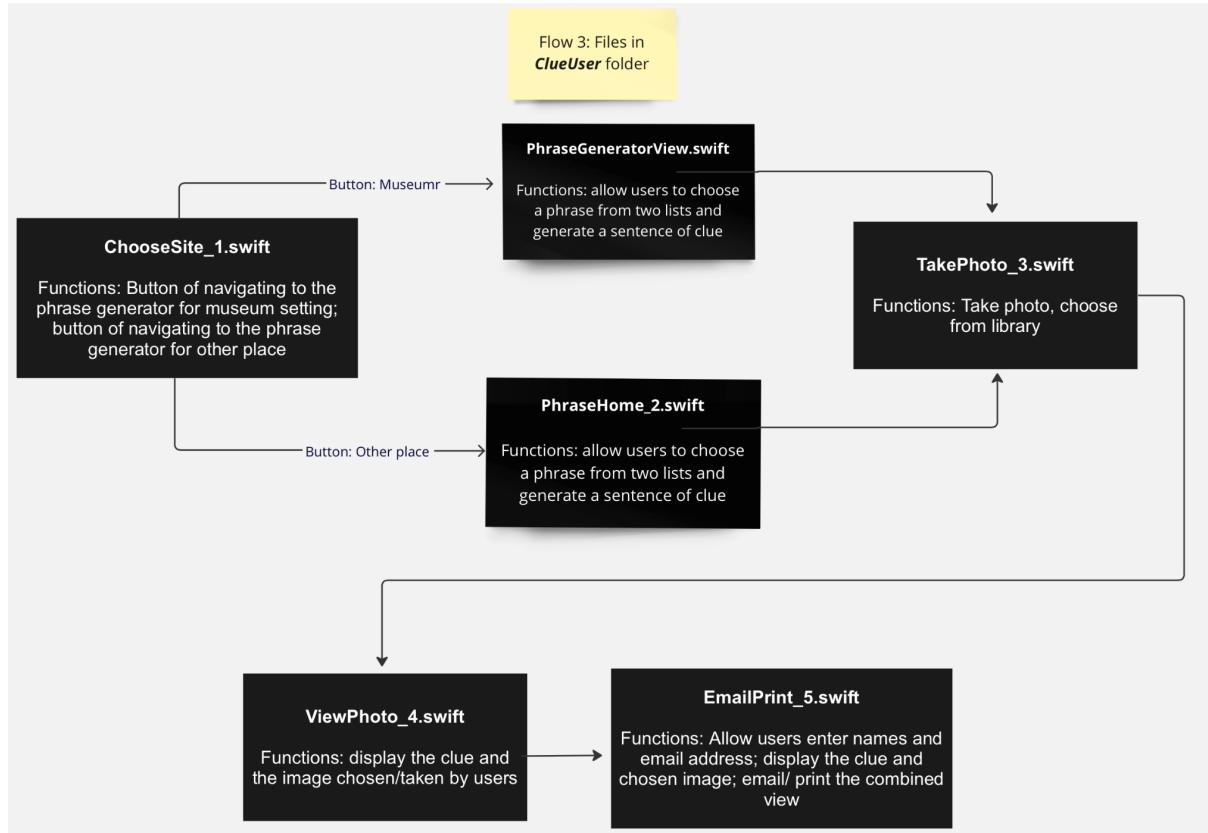


Figure 3.14: Architecture of the first iteration, flow 3

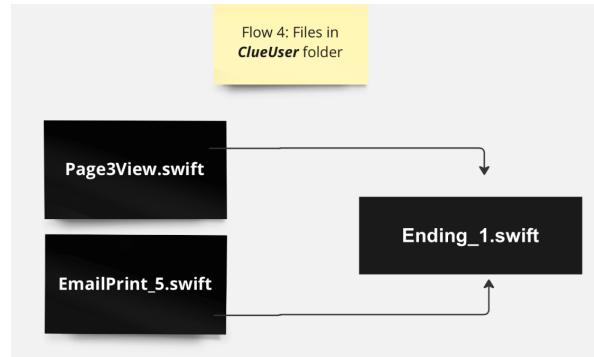


Figure 3.15: Architecture of the first iteration, flow 4

The second iteration

In the second iteration of the codebase, the Don't Repeat Yourself (DRY) principle was utilized, aiming for efficient coding and minimizing redundant code and coupling. This ensures that any modification of a single piece of code will not necessitate attention to logically unrelated code [78]. Instead of duplicating code, logic sharing can be abstracted into a common component for synchronization purposes. To implement the DRY principle in this project, the second iteration utilized a new struct, "GameState," and shared view components to enable dynamic control of views by controller components. This enhancement facilitated convenient and synchronous modification of the code for both the "use picture clue" and "use clue generator" functionalities. The new architecture is shown in Figure 3.17.

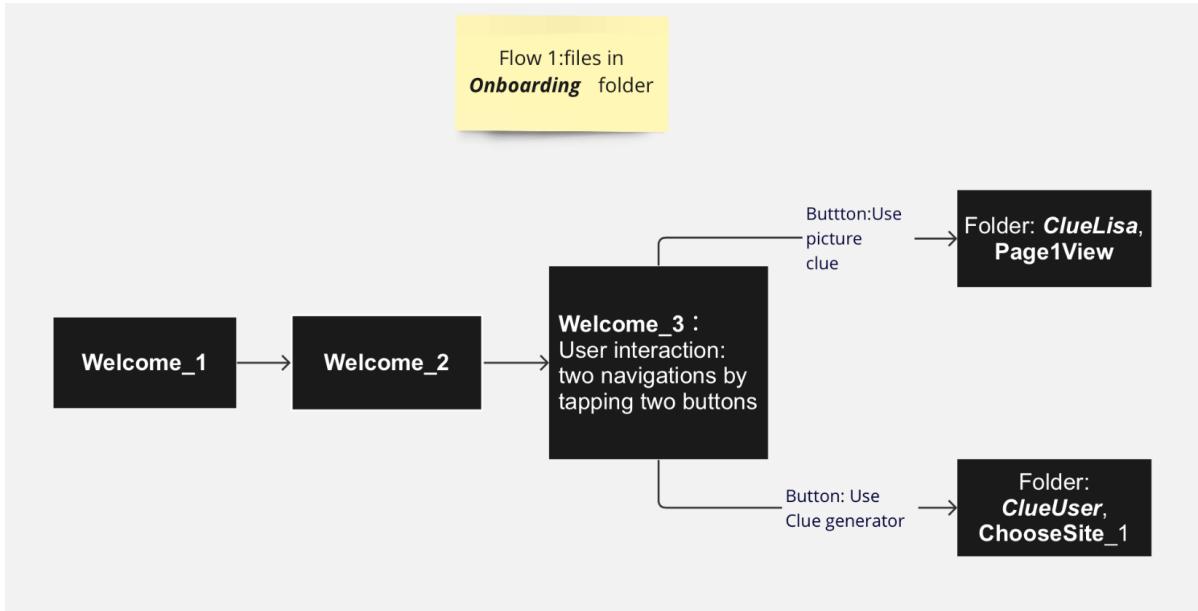


Figure 3.16: The second architecture, flow 1 (except helpers)

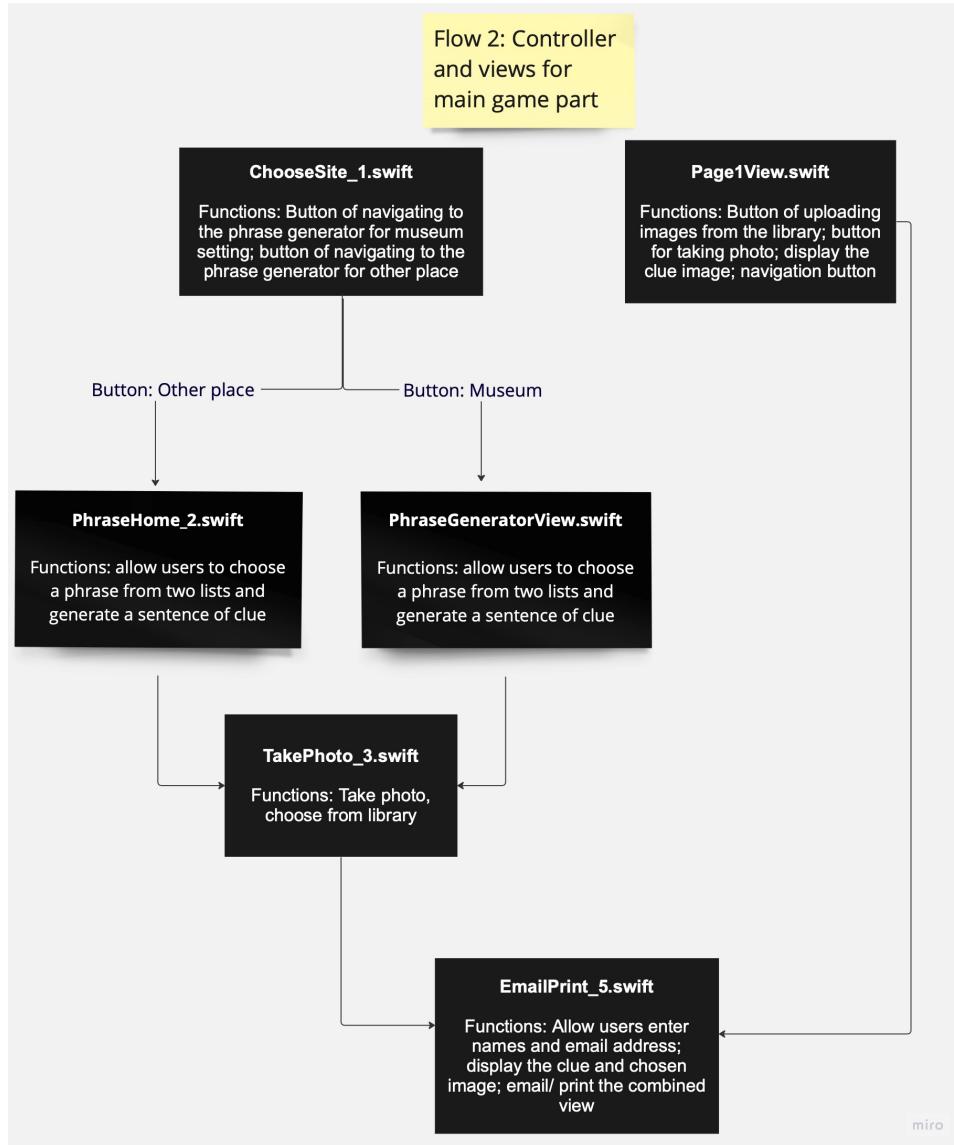


Figure 3.17: The second architecture, flow 2 (except helpers)

Conclusion

The adapted Model-View-Controller (MVC) architecture pattern offers both advantages and disadvantages for the project. The simple interactions in this project result in relatively straightforward communication between views and controllers. Specifically, when a user submits a request via the view to the controller, the controller is able to update the view state accordingly. Additionally, the bidirectional communication between the view and the controller enhances efficiency, making the code more readable. However, there are potential drawbacks to the increased coupling between views and controllers, such as challenges in code maintenance and extensibility. Thus, I harmonized the intricacy of the code with the coupling between controllers and views through the integration of helpers' codes. As the application expands to encompass more complex functions, the architecture may need to be enhanced. For example, future additions could include allowing users to interactively edit phrases in the clue generator. In this scenario, the Model-View-ViewModel (MVVM) pattern would be more appropriate for managing interactive data^[79], as it offers a more clean model to handle the increased data requirements. Aside from implementing a concise model, error-handling methods were utilized to conduct efficient debugging. After two iterations of the codebase, the code is now readable, improvable, and extensible for future development.

Chapter 4

Evaluation

This chapter aims to introduce the final evaluation of the I Spy Game app from both the design and development perspectives. The evaluation included unit testing, integration testing, and system testing of the codebase, as well as a user acceptance test to assess the app's functionality, user expectations, and user interface usability from a human-computer interaction perspective. The objective of the software evaluation is to analyze the app's functionality and determine whether it meets user expectations and evaluate the user interface's friendliness. User acceptance evaluation aims to analyse the usability of the app and determine if utilizing it can enhance the overall quality of life for people with dementia and their informal caregivers.

4.1 Software Evaluation

Prior to deploying the application in a real-world context with actual users, I initiated a comprehensive evaluation of the codebase's functionality. Employing unit testing strategies, every function and interactive element was rigorously examined to ensure the implemented code effectively encapsulated the envisioned user experience and interaction. For instance, all buttons linked to navigation were scrutinized to verify their ability to accurately guide users to the desired view.

Subsequently, integration testing was conducted to examine the collaborative functionality of multiple code segments. A salient example of this process involved verifying the accuracy of the data flow relating to image capture, and its subsequent transmission to the email/print view, ensuring the correct image, as selected by the user, was accurately conveyed.

Lastly, system testing was undertaken to assess the comprehensive functionality of the application, including all its components and the workflow of the entire user interface. For instance, the application was tested on various iPad models with differing screen sizes and iOS system versions.

The aforementioned testing phases were successfully completed, thereby establishing a robust foundation for the subsequent user acceptance testing phase. This critical stage is designed to expose the application to real-world users and authentic usage environments. Evidence of the application's functionality can be observed in Figure 4.1.

4.2 User Acceptance Evaluation

The purpose of the user acceptance evaluation is to assess the user experience and the impact of using the app on user engagement with museums, social confidence, and relationships. To obtain the most authentic feedback, this evaluation utilized a user study that aimed to replicate real-life usage circumstances to the greatest extent possible. The user study took place during a Tuesday Tea Party event at the RWA Museum, an initiative that provides dementia patients with complimentary access to exhibitions and an inclusive afternoon tea session with all attendees. Collaboration with the coordinator at the RWA facilitated the integration of the app into the event, enabling real-world visitor usage for evaluation. Five pairs comprising individuals with dementia and their respective loved ones participated in the app testing, alongside museum and Alzheimer's Society staff members (table 4.1). Evaluation

4.2. USER ACCEPTANCE EVALUATION

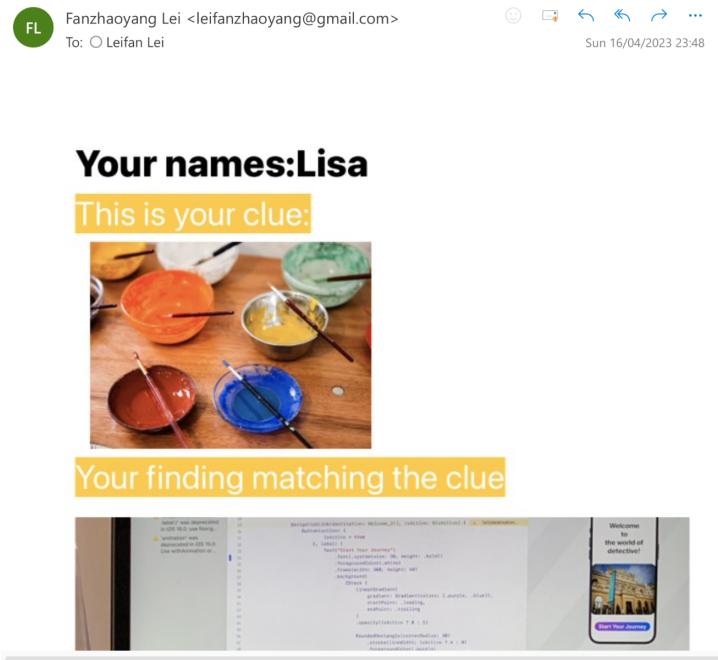


Figure 4.1: Successful test example: the screenshot of a sample email received by a user in an email website.

Name	Loved One's Name	dementia diagnosis	Program Coordinator	Group Assigned
Tara	Neil	Neil has dementia	n/a	Group 2
Penelope	Gabriel	Gabriel has dementia	n/a	Group 3
Blair	Jennie	Jennie has dementia	n/a	Group 3
Mary	Lucy	Lucy has dementia	n/a	Group 1
Noah	n/a	Noah has dementia	n/a	Group 1
Helen	n/a	n/a	RWA museum	Group 3
Caroline	n/a	n/a	RWA museum	Group 3
Clara	n/a	n/a	Alzheimer's Society	Group 2
P1	n/a	n/a	research assistant	Group 3
P2	n/a	n/a	research assistant	Group 2

Table 4.1: Demographic Information of participants in an evaluation user study. The participants were divided into three groups, with each group either receiving or delivering (in the case of research assistants) varying levels of technical assistance.

outcomes were derived from observations of participant interactions with the app within the museum setting, an interview with a couple consisting of an individual with dementia and their spouse, and discussions with two museum staff members and the Alzheimer's Society coordinator.

Participant App Usage Observation: Findings and Analysis

The observational phase commenced with the participants' tour of the exhibition and extended into the afternoon tea social activity. This scenario facilitated interaction between participants and unfamiliar individuals, with a critical emphasis on sharing their experiences with the app. Participants were segregated into three groups (see Table 4.1), each receiving varying degrees of assistance, as follows:

- **Group 1:** Comprehensive guidance on app usage was provided to this group.
- **Group 2:** The research assistant addressed questions about the app and solicited feedback on the user interface design.
- **Group 3:** The research assistant did not directly answer questions about using the app. Participants in this group were encouraged to experiment and share their thoughts on button designs and functionality when questions arose.

4.2. USER ACCEPTANCE EVALUATION

The stratification of participants into these groups supports the assessment of the app's usability and the intuitiveness of its interface. By offering different levels of assistance to each group, it is possible to discern which facets of the app are user-friendly and which may necessitate enhancement. Moreover, this methodology presents an opportunity to gather feedback about user experiences promptly from groups 2 and 3, thereby improving the efficiency and authenticity of the feedback acquisition process.

At the onset of the game, varying levels of confusion were exhibited among the fully guided group and the other two groups. Tara and Neil, members of the second group, expressed their confusion. Tara remarked, "I don't understand what this app asks me to do. What is the flow of playing it?" They also offered suggestions for improvement, with Tara suggesting, "It would be great if the 'startup' process pages could outline the flow." In contrast, participants in Group 1 commenced gameplay smoothly, owing to their comprehensive guidance and prior introduction to the app.

Another distinct difference between the groups was their awareness of the two different game modes. Participants in Group 1, prompted by the research assistant, attempted the "clue generator" mode after engaging with the "picture" mode. Conversely, the other two groups faced difficulties after completing a round of the game with one clue. Blare, who was in group three, commented, "*After taking the picture and finishing emailing, I assumed the game was over because the 'Back' button on the last page did not revert to the page that allowed us to select the game mode.*" This feedback suggests that the design of the 'Back' button may not be entirely user-friendly. The button fails to consider novice users, as its non-direct navigation causes users to forget about the alternative game mode. Moreover, the design of the button that only takes users back one view can become tedious for those who repeatedly tap it. An improved design might include two "Back" buttons: one to return to the previous page and another to reset the game, thereby reverting to the view that allows the selection of the clue mode.

Collectively, participants across all groups expressed their enjoyment of the game. Caregivers frequently indicated their appreciation for the game, noting its inclusive design that engages not only individuals with dementia but also themselves. One caregiver, Tara, commented, "Interesting idea! It involves both the cared and cared for". Such positive feedback about the application suggests its potential to augment caregiver satisfaction and foster a stronger bond between caregivers and those they care for. Moreover, during observations, participants were observed to stop at certain artwork and discuss its details with others, which suggests that the application encouraged engagement with the exhibition. This finding indicates that the application not only encouraged engagement with the exhibition but also promoted further reflection on the exhibits.

After completing their tour of the exhibition, participants were guided to a communal space for afternoon tea alongside other visitors. I observed their interactions during this social activity to gauge the potential impact of the app on their social engagement. Participants displayed excitement upon receiving printouts of their discoveries, suggesting that these printouts served as a form of reward, thereby contributing to a joyful atmosphere. An example of the printout can be seen in Figure 4.2. Observationally, all individuals with dementia engaged in conversations with their carers reflecting on their gameplay experience. Some even shared the content of their printouts with individuals beyond their caregivers. The impact of the app was further explored in subsequent interviews with returning visitors and museum staff members, where comparisons were made between afternoon tea experiences with and without the app. Despite the uplifted atmosphere attributed to the game, it is essential to gather more evidence to substantiate claims that this app can bolster long-term social confidence among users.

In conclusion, Group One, with complete guidance, navigated the app more adeptly than Group Two, with on-demand assistance, this indicated that the app lacks sufficient intuitiveness for novice users. Feedback from Group Three offered insights into potential design modifications to enrich the user experience, particularly regarding button design and functionality. Observations of users while using the app in a museum indicate that the app can create opportunities for interaction between people with dementia and their loved ones and stimulate deeper thinking while viewing artworks, thus enhancing engagement.

4.2.1 Insights From User Interviews

Four interviews were conducted following the app testing activity at the museum. These interviews

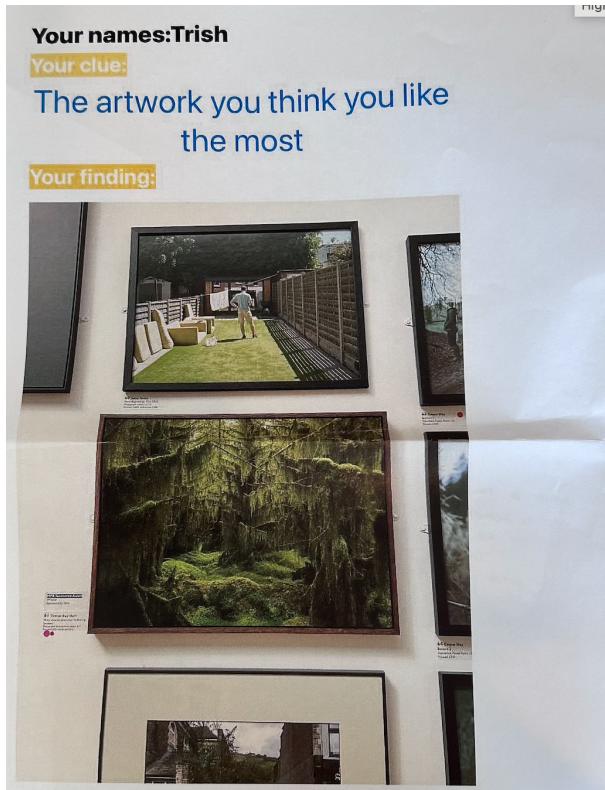


Figure 4.2: An example of the printouts distributed to participants during the afternoon tea.

involved discussions with two primary user groups: individuals with dementia and their caregivers, as well as museum staff members. Additionally, feedback was obtained from the coordinator of the Alzheimer's Society.

Interview with a person with dementia and their informal carer

Principal Participants The principal participants in this user-centred design process were Penelope and Gabriel, a couple of primary target users, selected for their active involvement throughout. Their participation commenced with the initial co-design workshop, where they communicated their expectations to inform the design and user interface concepts. The duo also attended the subsequent co-design workshop, where they evaluated the prototype and offered invaluable suggestions for its enhancement. Penelope and Gabriel were selected as our principal participants, partly due to their openness and adaptability towards technology, a crucial characteristic of this endeavour. As for their individual technology proficiency, Penelope, the caregiver, demonstrated considerable familiarity with applications, enhancing her value to the design process. Gabriel, diagnosed with dementia, exhibited limited proficiency with technology. However, his ability to articulate his feelings and engage in dialogue made him an equally significant participant. Owing to the couple's familiarity, eagerness to participate, and creativity, they were assigned to Group Three (the independent group for app testing). This decision was made to gain a more in-depth insight into their experiences with the app and to gather more authentic feedback on the user interface.

Interview method The interview questions were compartmentalized into four distinct themes: their museum viewing experience, interactions between them, social confidence, and possible enhancements of the app (refer to Appendix A). The interview was conducted using the semi-structured method. The semi-structured interview serves as a data collection technique that enhances the authenticity of gathered information and imparts flexibility to the interview process [80]. This method is particularly apt for interviewing individuals with dementia, as it permits the interviewer to modify the questions and pose follow-up inquiries flexibly, contingent on the participants' responses. Such a flexible interview structure allows individuals with dementia to express their thoughts and adapt to their requirements effectively. The semi-structured interviews conducted with Penelope and Gabriel facilitated a more comprehensive

4.2. USER ACCEPTANCE EVALUATION

feedback collection and a more compelling evaluation.

Interview Feedback The functionality of the printouts, serving as reminders of the users' gaming experience, can be substantiated through evidence obtained from the interview. During the discussion of question A1 in Appendix A, Penelope and Gabriel were prompted to recount a memorable moment from their gaming experience. The following dialogue ensued:

Penelope: "Do you remember what we discovered?"

Gabriel: "No."

Penelope: "Look at the pictures."

Upon reviewing the images in the printouts, Gabriel recalled their exploration within the exhibition and shared his rationale for selecting that particular image. This instance substantiates that the printout functionality can effectively assist individuals with dementia in recalling their experiences within the art gallery.

The influence of the application on their museum viewing experience was also a subject of our discussion. Penelope opined that the app introduced a novel manner of engagement with the exhibition, leading to enhanced visitor involvement. They compared this experience with their prior gallery viewing encounters devoid of a gaming application like the I Spy Game. Penelope stated, "In any art gallery, people often just wander around aimlessly." They conveyed that their enjoyment of viewing an exhibition was augmented when a game was incorporated.

Penelope: "Do you think it was better to do that rather than just wandering around?"

Gabriel: "Yes. Because you're on the hunt for something."

This shared sentiment indicates that the application can increase the visitors' inclination towards viewing the exhibition, and enhance their enjoyment during the experience.

Another aspect they highlighted, which could potentially heighten engagement during museum visits, was the app's ability to prompt them to concentrate on specific artworks and stimulate conversation about these pieces. The application provided them with meaningful clues related to specific descriptions, obliging them to zero in on certain artworks and exchange views or impressions about those particular pieces. Penelope noted, "*you come to go and see everything but you don't, you know, and it's good to actually look at a particular picture, and just talk about what you can see in the picture.*" This concentrated approach allows visitors to devote time to appreciating the artworks and foster discussions about them. Such interactions can strengthen their bond. For instance:

Penelope: "I saw a picture of the underground; it's part of my childhood."

Gabriel: "Yes, your childhood in London."

In summary, encouraging focused attention on certain artworks can lead visitors to spend more time examining specific exhibits. This can in turn generate deeper and more meaningful conversations, which could potentially strengthen their bond through these interactions.

The impact provided by the app on their social confidence is also discussed in our interview. Following the semi-structured interview approach, based on the answer of the app brought them more enjoyment in the museum, I asked a follow-up question: "Would you feel more confident to go to a museum if you know there would be an app provided for you to use?". Then we discuss the enhancement of the accessibility of the museum. Penelope: "We certainly would like to go to places like this. you don't have to try and wander around. Especially for Gabriel, there was something for him to do in the gallery." They also compare their feelings of the museum with an app like I Spy Game, which is dementia friendly, and a normal museum viewing experience. Penelope: "I think makes it more enjoyable to do that when we went to another museum recently. But it would have been good to have something like that there." Their feeling showed that the game not only makes the experience more enjoyable but also its dementia-friendly feature makes the museum more accessible.

Another potential benefit of this application is its capacity to stimulate conversation among unfamiliar individuals within a museum setting. When queried about their afternoon tea experience, Gabriel expressed, "*I enjoy talking with people.*" Similarly, Penelope stated, "*This application encourages us to engage with everyone.*" Their responses suggest that the game experience encouraged them to initiate

4.2. USER ACCEPTANCE EVALUATION

discussions with others. However, this outcome may warrant further assessment, including more extensive interviews with a broader participant pool, as the result could be influenced by individual personality traits. Nonetheless, based on the observations and this interview, it is plausible to suggest that the application could potentially enhance users' social interaction.

Despite receiving positive feedback during the interview, there were also critical remarks that paved the way for further enhancements. The suggestions predominantly pertained to refining the user interface (UI) to make it more intuitive. Participants expressed difficulties with pages that featured more complex task flow and navigation, such as the page for locating relevant artwork, capturing a photo, and then advancing to the subsequent screen. They also found it challenging to return to the start page after completing a round of play.

Penelope, expressed her confusion, stating, "*I found it difficult to navigate, it felt as if I were going in circles because I didn't know how to move away.*" The complexity of the UI, with its plethora of buttons, seemed to overwhelm users, making them forget each button's unique function. Penelope offered some suggestions for making the process flow more transparent. Reflecting on her words, "*I'm not sure if arrows would be useful, or perhaps just distinct sections. Directions such as "Now do this" could be helpful. Because we got a bit stuck and needed assistance*". This inspired a design concept aimed at enhancing the UI to offer more intuitive cues to users. For example, after a user captures a photo, the "use this photo" button could be emphasized through methods such as animation, enlargement, or colour modification. This strategy could guide users towards the appropriate option among a multitude of buttons. Consequently, this modification has the potential to augment user experience by promoting a more efficient interaction process.

Another recommendation put forth by Penelope and Gabriel involved clarifying the design of the ending page and incorporating a restart function. Upon completing a round of selecting clues, taking photos, and emailing or printing their work, users are directed to a concluding page that encourages them to share their experiences by using the button "next". However, to return to the page that allows them to choose a new clue, they must press "back" four times. They expressed confusion when pressing "back" in an attempt to choose a new clue, only to be redirected to the photo-taking page. This issue was not only raised by Penelope and Gabriel but was also observed among other participants who became stuck and discontinued using the app as a result. To address this challenge, I propose adding a new button labelled, "Hi detective, start a new case by tapping here." This feature will aid users in launching a new round and experimenting with different clues, thereby fostering a wide-ranging exploration of various topics. Consequently, this could generate a diverse range of discussion points during play, enabling them to engage in a variety of in-depth conversations and potentially strengthening their interpersonal relationships.

In conclusion, the interview with Gabriel and Penelope suggested that the application has the potential to fulfil their expectations. It appeared to enhance the enjoyment of museum viewing, foster communication between individuals with dementia and their caregivers, and transform the museum into a more accessible and dementia-friendly public space. Moreover, this could boost their social confidence. However, certain elements of confusion encountered while using the application could potentially create discomfort in utilizing technology within a museum setting, which might subsequently diminish their social confidence.

Interview with three staff members

Three additional interviews were conducted with museum staff members and the coordinator of the local Alzheimer's society. These individuals represent another primary user group for this application, overseeing the museum setting, organizing activities for people with dementia, and assisting participants during these activities. Given the substantial data provided by these interviews and the similarity in perspectives, this section utilized a thematic analysis approach, a method known for its deductive potential [81]. The thematic analysis process conducted in this section entailed:

1. Data cleaning
2. Primary reading
3. Generation of data codes

4.2. USER ACCEPTANCE EVALUATION

4. Identification of themes
5. Theme definition

This process was iterated twice for revising the themes to ensure they matched the data content. The initial code and the articles defined are provided in Appendix B and C. The data gleaned from these interviews are of significant value, as each of the three interviewees observed the entire process of participants using the application within the museum environment. In addition, they provided feedback from a more professional perspective concerning dementia, thereby contributing to a comprehensive understanding of the app's impact and usability.

RWA staff members

Caroline and Helen from the RWA provided feedback and observational results, focusing on the museum experience for both individuals with dementia and their caregivers. After thematic analysis, the data gathered from their interviews were categorized into two themes: “positive aspects” and “areas for improvement”. A particularly notable positive impact observed during the activity was the application’s capacity to enhance enjoyment during the afternoon tea. Helen commented, *“I could see that everyone who received a printed picture at the tea tables was delighted with that.”* Caroline added, *“I liked the idea of the photo to print out, giving people a tangible, visual reminder of the exhibition.”* These responses suggest that the application has the potential to enrich social activities within a museum context.

They also offered insights regarding the application’s impact on museum accessibility, drawing from their extensive experience as museum workers. They observed participants examining artwork details autonomously, contrasting this with traditional museum experiences that often require guidance from a tour guide. Caroline stated, *“It would help make areas like galleries more accessible without a guide, lowering the barrier to entry, or modes of access.”* They also noticed that participants were more engaged and energetic when a game facilitated their gallery viewing. Caroline also mentioned, *“it improved their confidence to visit galleries or exhibitions, increasing enjoyment, and with the image takeaway providing a means to recall the day.”* Thus, the application can make the museum tour experience more attractive and accessible by introducing a playful element with loved ones, and the printed photo serves as a tangible memento of the day’s activities.

Their most significant concern revolved around the observation that the application could potentially confuse individuals with dementia if used without guidance. Helen suggested the possibility of offering two versions of the game to cater to people with varying degrees of dementia diagnosis. She remarked,

“Some pairs were unable to use the game because the person with dementia could not understand it. Perhaps there could be an ‘advanced’ option, for people with more advanced dementia and their carer, where the instruction is completely basic with no detectives/clues or anything, but simply says ‘take a photo of a picture you like in the exhibition’ and then it could ask you some more prompt questions after that?”

Caroline echoed this suggestion, proposing *“perhaps a simpler UI, a one or two button UI to get an instant prompt.”* Caroline also voiced concerns about potential confusion leading to feelings of insecurity among visitors, which is undesirable. To address this, building on Helen’s idea, the starting page could include a feature allowing users to select between the current version or a simplified version that only includes steps for providing an instant clue and uploading a photo of the finding. This button could be labelled “short-time play version” instead of “Simple version” to avoid causing distress among individuals with dementia, preventing them from feeling their diagnosis differentiates them from others. Consequently, the application could become more accessible to a wider range of individuals with dementia.

Further recommendations were also proposed concerning the clue generator. The “clues” in this game significantly contribute to fostering in-depth discussions and prompting profound thinking among users. As Caroline noted, *“I would incorporate more picture clues, not just a single one related to the paintings. I assume some people prefer visual clues.”* A game mode with picture clues could be more appropriate for players who find the clue generator overly complex. Investing more effort in establishing picture clues could prove valuable, particularly for those with advanced dementia diagnoses who prefer visual stimuli [67].

4.3. EVALUATION SUMMARY AND FINDINGS

The coordinator of Alzheimer's Society

Clara, the coordinator of the Alzheimer's Society, accompanied individuals with dementia and their caregivers as they used the application within the museum setting. During the interview, she shared her observations, analysis, and suggestions for potential improvements, drawing from her extensive knowledge of dementia care. The data gathered from this interview was analyzed using the thematic analysis approach (Appendix B).

During the interview, Clara emphasized the potential advantage of the application, extending beyond the museum viewing experience discussed in previous interviews, and encompassing aspects of non-pharmacological dementia therapy. We deliberated on the multiple features that enable sharing of the museum viewing experience. Clara stated, "*Printouts, including the clues, can act as a reflective exercise for people with dementia.*" Activities like these can encourage reminiscence, thus enhancing memory and consciousness in individuals with dementia [82]. Clara also mentioned, "*The activity can be shared with a caregiver, friend, or across generations, which can be beneficial for them. The email option can help facilitate this sharing.*" This encourages communication and sharing of experiences with others, which is advantageous for individuals with dementia, helping them maintain self-awareness [83]. From Clara's dementia care perspective, the game offers reflective exercises and opportunities for communication with others, which can contribute to alleviating dementia symptoms.

Clara also recognized the broad applicability of the application. As it was designed based on expectations identified in previous co-design workshops, the application was developed to be suitable not only for RWA but also for other museums and even home settings. Clara stated, "*This is a prototype that can be rolled out across different galleries/museums/places.*" The design also accounted for the quick turnover of exhibitions, and therefore the clue generator encompasses multiple topics. Clara noted, "*Clues can be used regardless of the exhibition, less need to update.*" She further mentioned, "*It is suitable for many demographics.*" Her feedback implies that the application holds promise for widespread use, thereby potentially benefiting a larger population.

4.3 Evaluation Summary and Findings

In summary, compared to the conventional software testing process, user acceptance testing has proven instrumental in identifying design inadequacies from the user's perspective.

The evaluation consisted of an observational study that included twelve participants, a comprehensive interview with a representative couple, and discussions with seasoned professionals involved in museum operations and dementia-friendly initiatives.

The observational study highlighted an increase in participant engagement during museum exploration. Feedback from the representative couple postulated that the application might reinforce the bond between individuals with dementia and their informal caregivers, thereby enhancing their overall quality of life. Museum staff from RWA affirmed that the application enhanced museum accessibility. Furthermore, dialogue with the coordinator from the Alzheimer's Society suggested potential therapeutic benefits of the application for individuals diagnosed with dementia. In summation, the application was evaluated from diverse perspectives, underscoring its potential to align with user expectations. However, additional research is necessary to explore the proposals for a simpler and more intuitive user interface.

The following is a refined summary of future improvements, gleaned from user evaluations, that could be implemented to enhance the application:

1. (User Interface Simplification) Incorporate a button on the final page to facilitate the restarting of the game.
2. (User Interface Simplification) Improve clarity on pages containing complex user actions. For instance, emphasize the button needed for the current task.
3. (Content Enhancement) Increase the diversity of picture clues.

Chapter 5

Conclusion

5.1 Main Contributions and Achievements

This project's comprehensive process includes an exploration of the background of dementia life and treatment, the design and development of the application, and an evaluative user study.

Employment of design technologies

The design process is composed of three iterative cycles, each of which follows the four steps proposed in the spiral model design principle - plan, analyze challenges, build, and evaluate [1]. To incorporate user-centred design, these iterative cycles incorporated two co-design workshops, a feedback session, user acceptance testing with individuals with dementia and informal caregivers, along with interviews with museum staff during both the planning and evaluation phases. The initial plan in the first cycle was informed by data gathered in the first co-design workshop, while subsequent plans in the following cycles were shaped by a combination of the input based on my research and the data obtained from user studies during the evaluation of the previous cycle.

Iterative Prototype Development

Three prototypes were created during this process based on the feedback received, each incorporating modifications such as changes in game mechanics, button design, and the introduction of new features. These design cycles preceded the actual software development, taking advantage of the prototype's ease of modification. User studies in the design section involved participants providing feedback on a high-fidelity prototype created using Figma, a UI design tool. After three iterations, the prototype successfully met the user's expectations. The refined and evaluated prototype facilitated efficient software development preparation.

iOS Application Development

Subsequently, an iOS application was developed based on the iterative design prototype. The codebase underwent an improvement phase, reducing code duplication and coupling, thereby enhancing the overall architecture. I visualized the two versions of the code architecture using flow charts, as shown in section 3.5. Following the improvement, the codebase now exhibits reduced coupling, thus enhancing its potential for future updates and modifications. The software development process adhered to an adapted Model-View-Control architectural principle [2]. I tailored the "model" component to "helper" which was more fitting for this simple UI application that required fewer data passing. The successful completion of the software development stage paved the way for the final real-world evaluation user study.

Dual-Approach Evaluation: Software Analysis and User-Centric Studies

The final evaluation of this study entailed a dual approach: software analysis and user studies on the design and development. Prior to integrating the app into one of the RWA activities for testing, a series of

5.2. CURRENT STATE AND EVALUATION

software tests were conducted to ensure the app functioned as expected. This included unit, integration, and system testing to guarantee the smooth operation of each element and its interaction within the app. Upon successful completion of these codebase tests, coordination with the RWA museum, which holds monthly dementia-friendly activities, allows for the application to be tested during one of their events.

The User Acceptance Evaluation encompassed real-world testing, a follow-up interview with an individual with dementia and their informal carer, interviews with two museum staff members, and an interview with a representative from the local Alzheimer's society. During the testing session, over ten participants were provided with three iPads to sequentially test the app while viewing an exhibition at the RWA museum. The email and print functions were also tested on-site to ensure compatibility across various internet environments and devices. Subsequently, participant observation took place during an afternoon tea event, assessing the app's impact on social interactions among unfamiliar individuals. Printed outputs were distributed to respective participants to evaluate their potential in enhancing conversation, social engagement, and reminiscence therapy. The session was recorded for further data analysis.

In addition to observation, in-depth data was collected through interviews. A semi-structured interview was conducted with a couple who participated in the co-design process, providing a comprehensive evaluation of the app's user experience across four aspects: Museum Viewing, Relationship, Social Confidence, and Suggestions for the app (see Appendix A).

Three additional interviews were conducted with staff members possessing extensive knowledge and professional experience in museum management and dementia care. Thematic analysis was employed on the data collected from these interviews, involving data cleaning, coding, and theme identification. This process underwent two iterations to ensure data and theme alignment. The thematic analysis is shown in Appendices B and C. The evaluation results were synthesized from the analysis of data collected during observation and the four interviews.

5.2 Current State and Evaluation

Implementation of Design Plans The project has now successfully implemented all design plans established during three iterative design cycles (see 3.2.1, 3.3.1, 3.4.1 and 3.4.4). Each design plan, inspired by data from user studies, guided the construction of three prototypes. The software was developed to replicate the prototype, additionally incorporating the plan derived from the evaluation of the final prototype (see 3.4.4). The iOS application development effectively executed all desired features, fulfilling both user interface requirements and user expectations. After evaluating this iOS app, I developed a plan for future improvements (see Section 4.3).

Evaluation of the App's Desired Impact The evaluation user studies have demonstrated the app's potential to achieve the project's aim of enhancing the well-being of people with dementia and their informal caregivers. This is accomplished by improving their relationships, museum viewing engagement, and social activity participation. However, a long-term evaluation is required to assess impacts such as social confidence. Moreover, the final evaluation yielded further suggestions for improving this application. These suggestions hold potential for future development and enhancement of the app.

5.3 Limitation and Future Work

5.3.1 Limitation

Limitations of the Wizard of Oz Technique in Evaluating Prototypes

In the design cycles, the 'Wizard of Oz' technique was utilized during the evaluation stage, enabling participants to test the prototype. This method allows the testing of a rudimentary prototype by simulating the underdeveloped design components through an experimenter [84]. While the prototype incorporated navigation buttons, it lacked features such as photo taking, printing, and emailing. Therefore, in the co-design workshop aimed at evaluating the prototype, participants resorted to using a regular camera when a photo was needed, as opposed to using an in-app camera. Despite the usefulness

5.3. LIMITATION AND FUTURE WORK

of this method for the swift testing of designs, particularly pertinent for a spiral model project with frequent design alterations, it does carry some drawbacks. The primary issue is that the agent tasked with simulating the digital app's functionality must replicate the intended design as closely as possible [84]. This precise replication can be challenging, and as a result, the feedback gathered from user studies might be less accurate. Additionally, aspects of the design tested using the Wizard of Oz technique might be overlooked during testing, leading to a dearth of valuable feedback.

Limitation of User studies

Certain features and potential impacts of the application could not be evaluated in the final assessment at the RWA museum. For instance, the aspect of the game that could be played at home or in locations outside of the museum was not included. Consequently, the expectations expressed during the co-design workshop regarding the use of the game application at home remained untested, leaving its potential impact on daily life at home unverified. Although, from a software perspective, the utilization of these functions is expected to be feasible.

Some of the desired impacts of the app, such as an increase in social confidence, require long-term data collection from participants. For example, during one observed public activity, the atmosphere became more vibrant after using the application, and participants were encouraged to share their experiences and receive printouts akin to awards. However, this observation alone is insufficient to definitively conclude that their intrinsic social confidence has been enhanced, as the formation of social confidence occurs over a protracted period [85].

A principal limitation of the user studies pertained to the limited diversity of the participants. Despite the participation of roughly 20 individuals with dementia and their informal carers in total, the key couple involved in the main interviews exhibited a lack of variety. For future research, it is recommended to include two pairs, each comprised of an individual diagnosed with mid-stage and mild-stage dementia, respectively.

5.3.2 Future work

The outcomes of this research, which include results from the final evaluation, my observations during the development and testing processes, and additional research, provide a promising foundation for future work.

Participant feedback has yielded several suggestions for future enhancements, as detailed in 4.3. The first two suggestions listed can be addressed through modifications to the existing code (see appendix D). Moreover, for diversification of image clues, future developers may explore the use of AI picture generator technology, which would aid in generating varied visual stimuli for the visual player. Furthermore, some participants suggested that equipping the iPad with a case that includes a handle could facilitate easier handling of the device during the exhibition tour. This could potentially enhance usability and comfort for the users.

Beyond the suggestions from user studies, the development and testing process of the app also brought forth additional considerations. For instance, to ensure clarity of instructions, I utilized animations to emphasize critical text for players. On the onboarding page, names of the roles ("detective" and "assistant") are initially displayed (see figure 5.1 and 5.2). After a three-second interval, the first player's role description appears, followed by the second player's role description after another three seconds. This timing could be further optimized based on data regarding the reading speeds of older individuals, thereby enhancing the user experience for this demographic.

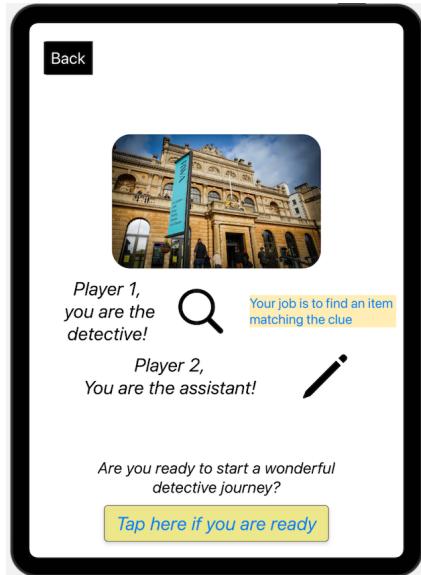


Figure 5.1: Text highlighting animation one: the first player's role description appears after three seconds

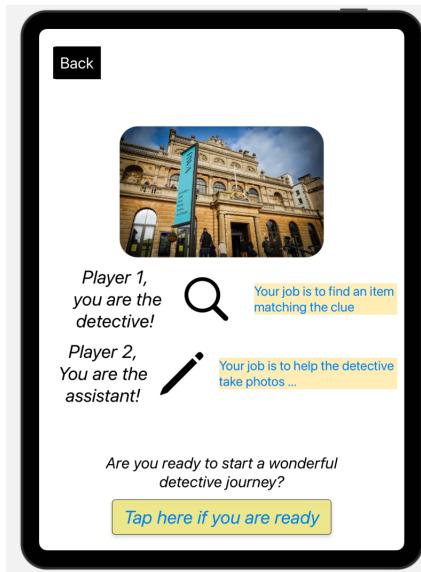


Figure 5.2: Text highlighting animation two: the second player's role description after another three seconds

For future testing, the incorporation of automated testing tools for iOS code could prove beneficial, especially in the context of any updates to the codebase. In addition, conducting an additional user study that specifically involves individuals with dementia would offer valuable insights. By examining every stage of the application's usage, we could ensure it is dementia-friendly. This rigorous testing approach would contribute to a more nuanced understanding of the application's efficacy, as well as highlight potential areas for further enhancement.

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Appendix A

Semi-structured interview questions for evaluation

A. Museum Viewing

1. Can you share your overall experience using the app with your partner? Were there any memorable moments? (How did these moments contribute to your overall experience and connection with your spouse?)
2. While using the app, did you feel more engaged with the museum exhibits? If so, can you provide an example of how the app facilitated this engagement?

B. Relationship

1. Have you and your spouse engaged in discussions about the items you found during the game? If so, how did those conversations make you feel?
2. How do you feel about your communication and connection with your spouse during the game? (Probe for feelings of closeness, understanding, and support)
3. Based on your experience with the app, do you believe it has positively influenced your relationship with your spouse? Can you provide any specific examples of how it has brought you closer together or improved your understanding of each other?
4. How did using the app change your interactions with your spouse during your visit to the museum? Did you notice any improvement in your communication or collaboration?
5. In what ways do you think the app has helped you in relating to your spouse on an emotional level?

C. Social Confidence

1. Did you notice any changes in your self-confidence during social situations at the museum as a result of using the app? For instance, did you feel more comfortable talking to other visitors or staff members, or in the afternoon tea?
2. Do you feel more confident participating in social activities with your spouse or others after using the app?
3. (For carers) Do you feel your spouse becomes more confident participating in social activities?

D. Potential improvements of the application

1. Do you have any suggestions for improvements to the app that you believe would further enhance its impact on social confidence, the experience of museum viewing and relationships?
2. How do you feel about the user interfaces such as buttons in the app?
3. How likely are you to recommend the app to others facing similar challenges? Why or why not?

Appendix B

Thematic Analysis of Interview: Clara from Alzheimer's Society

B.1 Initial Codes

The initial codes generated from the interview with Clara are:

1. Encourages engagement and conversation
2. Easy to follow
3. Personalizable clues
4. Can be used regardless of the exhibition
5. Can be rolled out across different galleries, museums, and places
6. Suitable for many demographics
7. Shareable via email
8. Shared activity with carer, friend, or intergenerational
9. Printouts act as a reflective exercise
10. Size of the iPad issue
11. Not clear for tech-unfamiliar people
12. Limited to photo-allowed exhibitions
13. Carer and friends needed to do the activity
14. More visual prompts needed
15. Some clues repetitive
16. Potential for emotion-incorporating questions
17. Word "partner" can be upsetting

B.2 Thematic Analysis Results

The thematic analysis of the interview with Clara resulted in two main themes: Positive Aspects and Room for Improvement.

B.2.1 Positive Aspects

The positive aspects that emerged from the interview include:

- Encourages engagement and conversation
- Can be used regardless of the exhibition
- Shared activity with carer, friend, or intergenerational
- Can be rolled out across different galleries, museums, and places
- Suitable for many demographics
- Personalizable clues
- Printouts act as a reflective exercise
- Easy to follow
- Shareable via email

B.2.2 Room for Improvement

Areas identified for improvement include:

- Size of the iPad issue
- Not clear for tech-unfamiliar people
- More visual prompts needed
- Care and friends needed to do the activity
- Some clues repetitive
- Potential for emotion-incorporating questions
- Word "partner" can be upsetting
- Limited to photo-allowed exhibitions

Appendix C

Thematic Analysis of Interviews: Carolina and Helen from the museum

C.1 Initial Codes

The initial codes generated from the interviews with Kat and Helen are:

1. Prefer simpler language and less steps to get to the activity
2. Liked the idea of photo printouts as takeaway reminders
3. Desire for expanded list of prompts, including emotions
4. App introduced confusion
5. Difficulty understanding the aim of the given picture prompt section
6. App could make galleries more accessible
7. App could increase confidence to visit galleries
8. Difficult to find 'use photo' button
9. Each stage needed explanation
10. Some instructions were confusing
11. Need for an advanced option for people with more advanced dementia
12. Suggestion for separate games for clarity
13. Printed pictures were appreciated

C.2 Thematic Analysis Results

The thematic analysis of the interviews with Carolina and Helen resulted in two main themes: Positive Aspects and Areas for Improvement.

C.2.1 Positive Aspects

The positive aspects that emerged from the interviews include:

- Liked the idea of photo printouts as takeaway reminders
- App could make galleries more accessible
- App could increase confidence to visit galleries
- Printed pictures were appreciated

C.2.2 Areas for Improvement

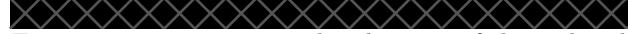
Areas identified for improvement include:

- Prefer simpler language and less steps to get to the activity
- Desire for expanded list of prompts, including emotions
- Need for a simpler UI
- App introduced confusion
- Difficulty understanding the aim of the given prompt section
- Difficult to find 'use photo' button
- Each stage needed explanation
- Some instructions were confusing
- Need for an advanced option for people with more advanced dementia
- Suggestion for separate games for clarity

Appendix D

Source code

The source code for the application is available at the following repository:



For access permissions and utilization of the code, please kindly contact the author.