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Master's Thesis

PicCo: Improved Communication  
between Elderly People & Geographically  
Remote Family Members through IoT Design

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2019

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Remote Family Members through IoT Design**

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A thesis submitted  
to the Graduate School of Creative Design Engineering, UNIST  
in partial fulfillment of the  
requirements for the degree of  
Professional Master of Design-Engineering

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01/03/2019

Approved by

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# PicCo: Improved Communication between Elderly People & Geographically Remote Family Members through IoT Design

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## Executive Summary

With the increase in the number of elderly people living alone, the social disconnect they are experiencing is an increasing issue. Through an interview study, we discovered a need for a socially uninterrupted connection, especially with remote family relationships. In practice, however, elderly users were discovered to have difficulty communicating with other family members, including children and grandchildren. A lack of time and the difference in communication methods appeared to compound these difficulties. To address these challenges, we explored existing communication methods for elderly users and their family members through a desktop study, to explore existing and appropriate communication methods for elderly users and family members living far away. Through this process, we discovered several findings from existing research. Specifically, clarity and simplicity in product or service design were identified. In addition, a requirement for an unobtrusive way in which communication could be achieved so as not to interfere with the day-to-day lives of family members. We proposed a concept that can be used as a new communication method to address these challenges. The elderly who live alone feel difficulty in communicating with their family because of the difference in contact methods used (analog and phone conversations vs. extensive and increasing use of various social media platforms within the Korean context). These issues were compounded by a lack of time due to busy life and work habits. A user-centered approach was the starting point for our PicCo concept. A challenge is to offer products in the most familiar way for the elderly living alone. The elderly and their adult children have different preferred interaction methods. However, existing products offer communication in only one way (one product or one application). This tends to interfere with the continued use of the product. We provide the most familiar method for each target. For older people who are familiar with physical products, we offer more intuitive, physical interaction points. In addition, we continue to develop the product by providing an application for adult children who consider accessibility to be important. In addition, PicCo provides communication clues in an unobtrusive way in the daily lives of users by adding 20 minutes of delay to upload images and voice notes. We conducted a usability evaluation for elderly users over the age of 65 to confirm the effectiveness of the PicCo concept. The usability evaluation was undertaken using a working prototype that implements the three main functions of the concept: recording, keeping image, and moving to next image. As a result, we identified some usability issues and opportunities for the concept's further development. By improving the directional recognition/functionality structure of the buttons and simplifying the use process, we were able to extend existing communication, which was limited to voice call, to a richer way of communication, using images and voices. Based on the understanding of the elderly, we extended the notion of elderly and family communication currently confined to existing device-based applications. By presenting considerations and development points

for future research, we finally suggest new design opportunities to provide elderly communication solutions.

Keywords: IoT Product Design, Unobtrusive Interaction, Inclusive Design, Communication





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## Chapter 1

# Introduction

### 1.1 BACKGROUND

With the increase in the number of elderly people living alone, the social disconnect they are experiencing is an increasing societal challenge. Indeed, 15% of the total elderly population suffer from depression, with social disruption the biggest cause of this depression (Figure 1).



**Figure 1. Problems facing older generations**

In a study of the Social Disconnectedness of elderly people (Cornwell et al., 2009), social isolation and the mental health of the elderly were found to have a strong association. In addition, through research on elderly depression and family relationships (Park, 1999), we found that improving family relationships can be helpful to empower the elderly and reduce depression. However, generally, seniors use limited communication methods (Bunz, 2012). Because of their low technology acceptance, they have limited access to digital communication channels(i.e. social media platforms), still using exclusively voice calls. This results in limits to richer communication with remote family members.

The current project proposes a design concept to address these challenges through an intervention that provides richer communication to the elderly and their family members who live far away.

### 1.2 RESEARCH AIM AND SCOPE

Through exploring user needs, this study aimed to suggest the most appropriate communication method for elderly living alone and their remotely located family members. We propose a new

communication method that encourages communication between the elderly and their family.

With these research aims in hand, we addressed the following two, related, research questions:

- ✓ What are the problems and needs of elderly living alone in communication with their geographically remote family members?
- ✓ What is the most appropriate interaction/communication method for the elderly living alone and their family?

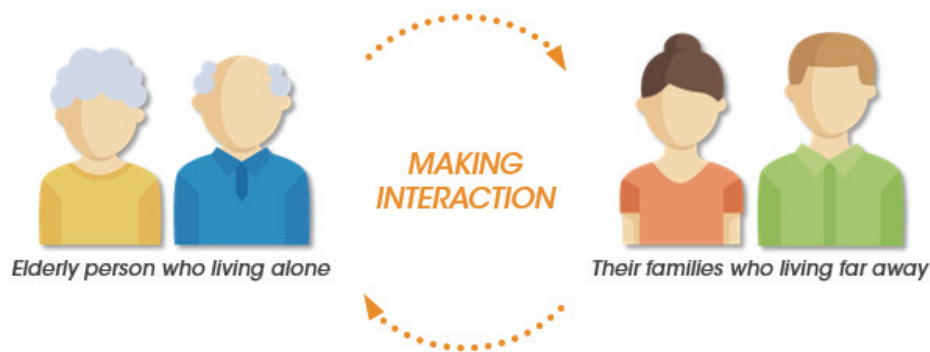


Figure 2. Research aim

## 1.3 RESEARCH PROCESS

### Design concept proposal and usability evaluation

In this study we present a design concept through needs and problem exploration and create a prototype to show product interaction. Using a semi-working prototype, the usability evaluation is carried out to find development points and suggest the best interaction and new communication method for the target user.

## 1.4 THESIS STRUCTURE

In this chapter, we explained the purpose and direction of this study. We investigated the rationale and prototype to check the usability and suitability of the concept.

In Chapter Two we emphasize the process of understanding the target user and discovering their needs and problems through desktop studies and interviews. Through a literature review, we explored existing research to understand users. We also identified the communication problems and needs currently faced by six targeted users through a personal inventory study to understand familiar interaction methods. After that, we observed the day of one elderly participant to understand the life of the target user.

In Chapter Three we discuss the design of a device to encourage communication between the elderly living alone and their remote families. We present usage context and usage scenarios. Based on a solution to the needs and problems found in the previous chapter, we created a working prototype to test and validate our design intervention.

In Chapter Four we describe the concept implementation process and the prototyping process. We also discuss design limitations, including the prototyping process. The prototype was used in usability evaluation described in the following chapters and contains the determination and the basis for the suitability of this process.

## Chapter 2

# Desktop Studies & Interview

In this chapter, we discuss a desktop study and interview to explore the problems and needs of the elderly in communication, exploring the most appropriate forms of communication.

### 2.1 LITERATURE REVIEW

A literature review was conducted to seek to understand user communication by exploring existing research on family communication. Through this existing research, we examined the needs and problems of the target users and the solutions presented by existing works. This was then applied to explore the potential of design opportunities.

#### *StoryPlace.me*

StoryPlace.me is a public location-based senior communication video service (Bentley et al., 2012). The study referred to the concept of Intimacy at a distance through the investigation of intergenerational communication. Older adults preferred to keep their own homes and have specific scheduled times of interaction with their adult children. The study also refers to the ubiquitous computing systems for awareness, which suggests that photos and notes are then prompted further at later and more convenient times. We obtained two findings from this study. Experiment participants in this study placed pictures at key locations in the house to recall memories of their families. They then used these photos as reminders of special events and precious times. Participants also continued to show the importance of the family and enhance their sense of calm and togetherness through new family communication tools.

#### *Home Talky*

Home Talky is a work aimed at developing SNS services for family members across every generation (Lee et al., 2017). This study identified the target user's needs as information related to the status of family members through related work, (Kang et al., 2015). The study also found that phone calls helped create emotional bonds between families rather than social networking platforms. Because voice call could convey a variety of information, such as tone and ambience, it creates a higher bond than other text-based media.

#### *G2G*

A study was conducted for G2G design, a shared calendar message system for grandparents and



grandchildren (Forghani et al., 2018). The Forghani et. al. study mentioned that communicating with parents and grandparents has a positive effect, but sometimes acts as a distraction to their children through related work of communication with grandparents over distance (Forghani et al., 2014). They also found the importance of feedback through experiments. Instead of sharing information on one side, sharing the reaction to shared content on both sides engages product use.

### ***Supporting the distributed family***

A study exploring support for the distributed family discusses the need for a conversational context (Evjemo et al., 2004). The study found that it was possible to provide a snapshot or a short video for creating and providing new communication clues as an auxiliary role of calling, which was also found to be the main communication method for the elderly.

### ***Revisited: Communication Media Use in the Grandparent/Grandchild Relationship***

The study investigated communication media use between grandparents and grandchildren in terms of relationship building (Bunz 2012). Exploring the technological acceptance of each generation and its reasons, the study (ibid) provides an understanding of the technical acceptance of elderly users. In particular, a need for research on elderly communication methods and technology was required to better identify design opportunities.

Though research on issues associated with communication and gerontology (the study of elderly users) has increased over the last decade, the literature in this area is still fairly limited compared to other topics (e.g., communication health-related issues). Studies that explore elderly use of communication technologies are even rarer.

### ***The Development of Customized Communication System for the Senior Living Alone***

A study on the development of customized communication Systems for the senior living alone presented solutions to elderly depression through communication with elderly living alone and their families (Kim et al., 2018). Communicating with family members was shown to be key in addressing psychological isolation to provide the human element for communicating to the elderly living alone.

## **2.2 IN-DEPTH INTERVIEW**

In-depth Interviews were performed to identify user problems and needs. Three elderly people aged 65 or older and three members of their families were interviewed for this purpose.

## Participants

After recruiting participants, we identified their technical level and frequency of contact with their families and conducted interview in a one-to-one format. In order to identify in-depth issues and needs, we asked them to indicate their relationships in interview responses and illustrate their existing communication approaches (Table 1).

**Table 1. In-depth interview participant information**

| Participant code | Relationship | Age | Information   | Communication characteristic                                  |
|------------------|--------------|-----|---|---|
| E01              | F01 mother   | 82  | <ul style="list-style-type: none"> <li>• Living alone, 4 immediate family members,</li> <li>• Low technology level</li> </ul> | Mainly using voice calls/<br>Communicating twice a month      |
| F01              | E01 daughter | 61  | <ul style="list-style-type: none"> <li>• Remote location,</li> <li>• Intermediate technology level</li> </ul>                 |   |
| E02              | F02 mother   | 80  | <ul style="list-style-type: none"> <li>• Living alone, 3 immediate family members,</li> <li>• Low technology level</li> </ul> | Mainly using voice calls/<br>Communicating three times a week |
| F02              | E02 grandson | 34  | <ul style="list-style-type: none"> <li>• Remote location,</li> <li>• High technology level</li> </ul>                         |   |
| E03              | F03 father   | 84  | <ul style="list-style-type: none"> <li>• Living alone, 5 immediate family members,</li> <li>• Low technology level</li> </ul> | Mainly using voice calls/<br>Communicating once a week        |
| F03              | E03 daughter | 52  | <ul style="list-style-type: none"> <li>• Remote location,</li> <li>• Intermediate technology level</li> </ul>                 |   |

## Interview Questions

Interview questions were made up of a total of five. Adopting a semi-structured approach, related questions were actively adding to extract more information from interviewees.

1. What do you do when you miss your family living outside of Korea? (For example, you can see family pictures on Facebook or call grandma.)
2. You are mainly in contact with grandma on the phone, do you have any other contact methods or tools with family members living far away? (Such as text messages or video calls)

3. How often do you usually contact other family members who live far away?
4. Do you have any problems or challenges in contacting with your family?
5. Do you have information that you would like to share with your family members or be provided continuously from family members?

Interviews were conducted in face-to-face and through video calls.

## Interview Findings

We found two main obstacles that participants had in communicating with their families through interviews (Figure3).



**Figure 3. Communication problem**

First, it was difficult for family members to call their parents because of a lack of time. Also, elderly parents hesitated to contact family members because of a perceived concern for interrupting their children's work and daily lives. Because the main communication between the elderly and their families was limited to phone calls, specific times were scheduled to contact each other. This also appeared to be a burden for our participants.

Also, differences in communication methods were identified as important factors that interfered with family communication. Family members preferred to communicate with text messages or mobile images and photos. However, elderly participants preferred to communicate via voice contact or visual images. There was a difference in individual technology acceptance, but there was a clear difference in the communication methods between the two target participants, which prevented them from contacting each other. Participants answered that they do not have enough existing products or services to solve these problems and felt a need for a new communication method.

## 2.3 PERSONAL INVENTORY & SHADOWING

We shadowed one of the interview participants to observe their daily life and to collect photographs of their personal inventory. Through personal inventory observations, we were able to discover some interesting insights, such as the items that the participant usually used, and the pictures related to their

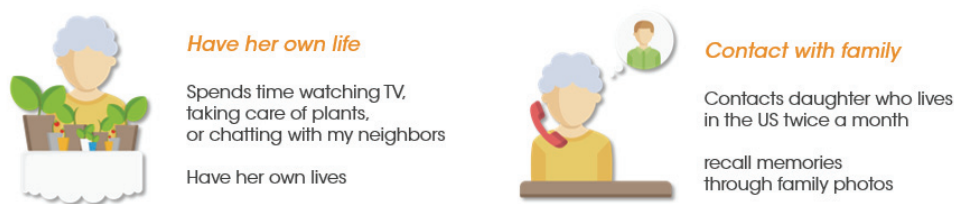
family (Figure 4).



**Figure 4. Personal inventory**

There were three broad insights discovered through the personal inventory of the participant. First, she hung frames or memorable items on the wall. Through the interview, she said that the walls were an eye-catching place, so she placed precious things on the wall to maximize visibility within her personal living space. She also made a photo collage of family members and placed them in the main living room, like dressing table or head of the bed. This gave her a sense of being with her family and was used to recall memories of her family. Finally, she used simple, familiar products. These objects were mainly composed of physical interactions and were used over long periods of time. She preferred simple things to use and had difficulties with new technology.

Shadowing proceeded from 9:00 am to 8:00 pm. We recorded her behavior and schedule, and we were able to obtain information through interviews about the times we did not observe.



**Figure 5. Shadowing**

Through shadowing, we were provided two insights (Figure 5). First, the participant enjoyed her own life. She did not want to be disturbed by the over-observation and over-connectivity of her family, enjoying an independent life, not just waiting for their contact. This is partially related with the concept of intimacy at a distance in the StoryPlace.me study (Bentley et al., 2012). She also contacted her daughter who lived far away through voice calls twice a month. She wonders about her family who lived far away, but the way of communication was limited to voice calls. There was no other way

to contact her, but instead she saw a lot of family photos to recall her memory with her daughter’s family. Her family photos were a method of memory recalling, which was important to her due to a limited width of communication (voice call only).

## 2.4 SUMMARY

Through the desktop studies, interview and participant observation, we were able to identify the following factor related to elderly, target user needs (Figure 6).



**Figure 6. Factor that target user need**

Elderly users preferred simple physical interactions and physical products. On the other hand, family members preferred low access services such as mobile phone applications and social media platforms (i.e. Kakao Talk). We found that both target users needed products that did not require time to use. Also, subjects discussed a need for unobtrusive means to interact with family members that would provide a clue to communication without interfering with their everyday lives.

Based on these findings, the next chapter sets out the design specification, including suggests towards the concept to meet identified user needs.

## Chapter 3

# Design Proposal

Based on the target user findings discussed in the previous chapter, we determined some of the important directions for concept design. We further propose our design concept: PicCo.

### 3.1 PROJECT DEFINITION

#### Concept purpose and direction

The current study aimed to identify appropriate communication interaction and usage context for the target user. To this end, results were analyzed to identify the necessary elements of the new communication concept. By evaluating its importance, we explored concepts which could solve the user problem and meet user needs.

#### Design Specification

Based upon the project's research phase, we set the following design specifications (Table 2).

**Table 2. Design specification**

| No. | Specification   | Impt. score (0-10) |
|-----|---|--------------------|
| 1   | Use familiar interaction for older users  | 10                 |
| 2   | Low time-consuming applications and product using processes                                     | 9                  |
| 3   | Three or fewer functions with physical products   | 9                  |
| 4   | Design uniformity of physical products and applications   | 4                  |
| 5   | Clear interaction feedback  | 8                  |
| 6   | Large-sized interaction element of physical product that is easy to recognize for elderly users | 9                  |
| 7   | Enough space between functional elements  | 9                  |
| 8   | A physical product that can be put on the wall  | 7                  |
| 9   | One-off sharing of data and optional archiving  | 6                  |
| 10  | Time difference upload of data  | 7                  |

Each item was scored according to its importance, which served as our design guideline. First, we needed to use familiar interaction methods for older users. By providing them with easy-to-understand interactions, we can drive sustained and effective use. In addition, low-time consuming product use processes that do not interfere with everyday life can create easily accessible and continuous use. Low-time consuming product allows us to solve time-consuming problems discovered through interviews. Considering the low technical capacity of the elderly users, it was necessary to simplify product function. According to the Nielsen Norman Group's Seniors as Web Users study, elderly users require clear and simple interactions (Pernice et al., 2013). Also, as identified in our previous studies, older users needed large, easy-to-understand interaction elements. And they say that a certain amount of space between the interaction elements, rather than a collection of dense elements, was helpful in understanding product function.

Further, as seen from the personal inventory carried out at the participant's home, the elderly participant placed their family images or meaningful objects in visible places on the wall. Therefore, we expected that products that can be hung on the wall may provide familiar using contexts to elderly users. In addition, one-off sharing of data and data upload of time differences could serve as part of daily life rather than just focusing on this communication to each user.

## **3.2 PicCo**

### **IoT product for family communication**

PicCo is an IoT product that enables communication between seniors and their families through images and sound. It consists of a physical product that allows intuitive physical interactions optimized for elderly users who may be unfamiliar with new technologies. PicCo's application design component complements the physical product to provide family members opportunity to send, store and retrieve photographs and voice messages. Through PicCo family members, friends and loved ones can easily share content. The concept also provides opportunity for elderly users to leave voice messages in response to photo content. By providing a 20-minute delay in uploading photos and messages, this product allows users to freely interact without disrupting everyday life activities and commitments. In this way PicCo provides communication clues through photos and voice messages between the elderly living alone and their families (Figure 7).



**Figure 7. Concept brief**

One of the biggest innovations is to offer products in the most familiar way for the elderly living alone and their families. The elderly and their adult children have different preferred interaction methods. However, existing products offer communication in only one way (one product or one application). This interferes with the continued use of the product. We provide the most familiar method for each target. For older people who are familiar with physical products, we offer more intuitive, physical interaction points. In addition, we continue to develop the product by providing an application for family members who consider accessibility to be important. In addition, PicCo provides communication clues in an unobtrusive way to the daily lives of users by adding a 20 minute of delay to upload images and sounds.

### **Physical Product**

PicCo consists of simple and basic physical buttons. These physical buttons were intended to be perceived intuitively by the target user, the elderly. There are three kinds of buttons, including the side button. Each part of the product has the function as shown in Figure8.





**Figure 8. Physical product detail**

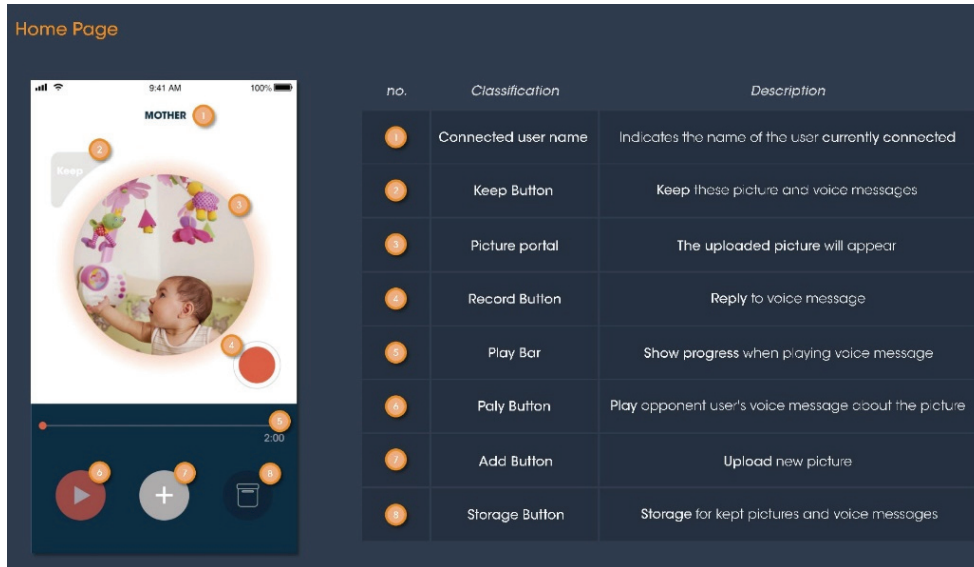
This product can be installed by attaching the bracket to the wall and then fitting it into the fixing part on the rear side. When a family member uploads an image through the application, it appears on the physical product display for one day (Figure 8, Display). If the user wants to keep the image for more than one day, they can press the keep button at the top of the product (Figure 8, Keep button). The button light turns on with an orange color. This image is then stored in one of five light indicators. Each light indicator stores the archived pictures and shows the number of pictures (Figure 8, Indicator). The first light at the bottom of the product indicates the photos uploaded that day. To remove the stored picture, the user presses the keep button again. The button turns off and the picture disappears. The next button is located on the side of the product and can be used to move to the next image (Figure 8, Next button). The user can press and hold the record button to save comments on the picture in the form of a voice message (Figure 8, Recording button). This voice message will also appear in the family member application 20 minutes later. Voice messages can only be created once per picture. Once the voice message has been created, recording button is used to play the voice reply from the family member. The update of the voice reply will be shown in a gradient on the photo border. It is designed to be easily understood by users of higher ages through physical buttons with clear feedback and simple interaction configuration.

## User Interface

PicCo is an IoT (Internet of Things) product that enables connection between smartphone application and the physical product. This application is for family members who care about accessibility. Based on the needs of the target user through the interview study, the interface is easily accessible. It has a home page, a photo add-on page, and a storage page. Users can send images to a physical product or receive voice messages about images.

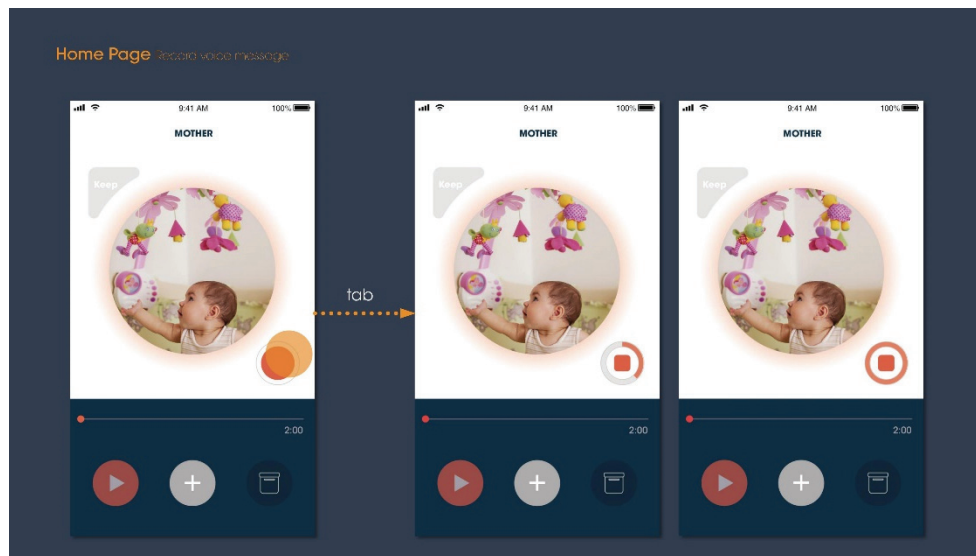
### Home Page

The home page is composed as follows (Figure 9).



**Figure 9. UI detail of Home Page**

The main page has similar interaction elements as the physical product; colors and forms are indicative of those used in the physical product (Figure 9). At the top, the name of the connected user is displayed (#1 in Figure 9). The center of the homepage is a picture portal, where the user can see images recently uploaded (#3 in Figure 9). At the top of the picture portal, like the physical product, a keep button is located, and the archived photo can be found on the storage page at the bottom right (#2 and 8 in Figure 9). When a voice message is uploaded for the picture, a color gradient is created on the picture portal side so that the user can recognize an upload. The uploaded voice message can be checked with the play button at bottom left and playback status can be checked with the play bar (#5 and 6 in Figure 9). The user can record and reply to voice messages with the record button located at the bottom of the picture portal (#4 in Figure 9). Using the add button at the bottom center, the user can go to the add picture page and add a new photo to send (#7 in Figure 9).

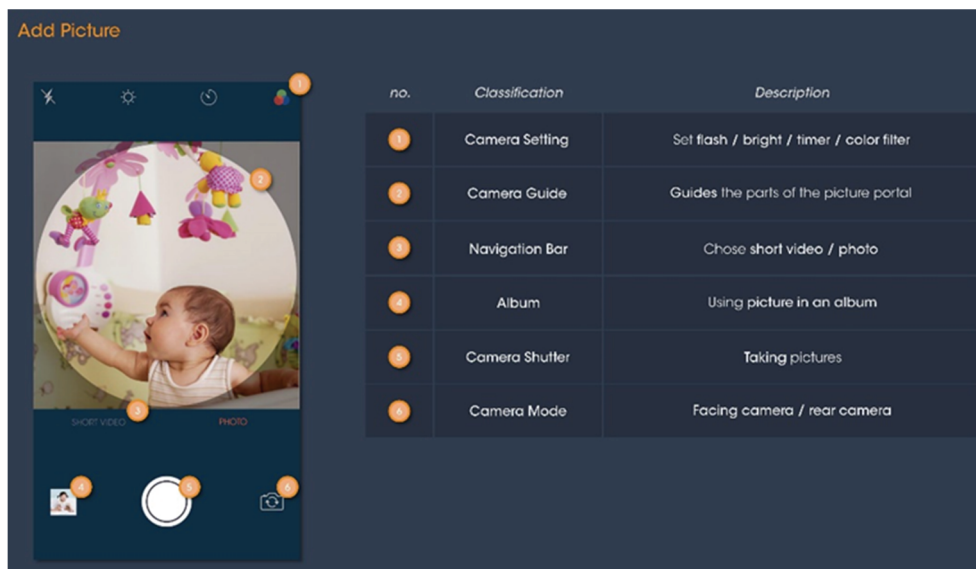


**Figure 10. UI detail of replying voice message**

When the user taps the record button to reply a voice message, an indicator of the recording progress is displayed (Figure 10). This voice reply appears on the physical product after 20 minutes and appears at a gradient on the display of the physical product in the same method as the application.

### **Add Picture**

On this page, family members can shoot and upload photos themselves. They can also import and use photos from their mobile phone photo albums (Figure 11).

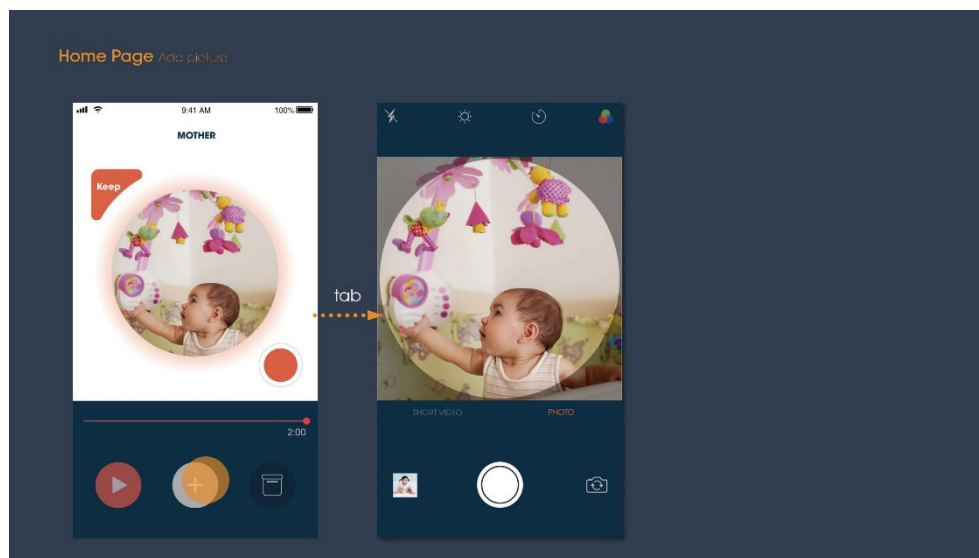


**Figure 11. UI detail of Adding Picture page**

At the top of this page are function icons for setting up the camera (#1 in Figure 11). In addition,

the onscreen camera guides users to more easily predict the range and type of images that will appear on the display (#2 in Figure 11). The navigation bar allows the user to choose the type of short video (up to a maximum length of 2 minutes), as well as the image (#3 in Figure 11). Through the album at the bottom left of the screen, the user can bring up a picture of the smartphone photo album (#4 in Figure 11). The camera shutter and camera modes in the bottom center are provided in a form and position similar to those of existing camera applications, making it easy for the user to recognize (#5 and 6 in Figure 11).

The add picture page can be moved using the add button at the bottom center of the homepage (Figure 12).

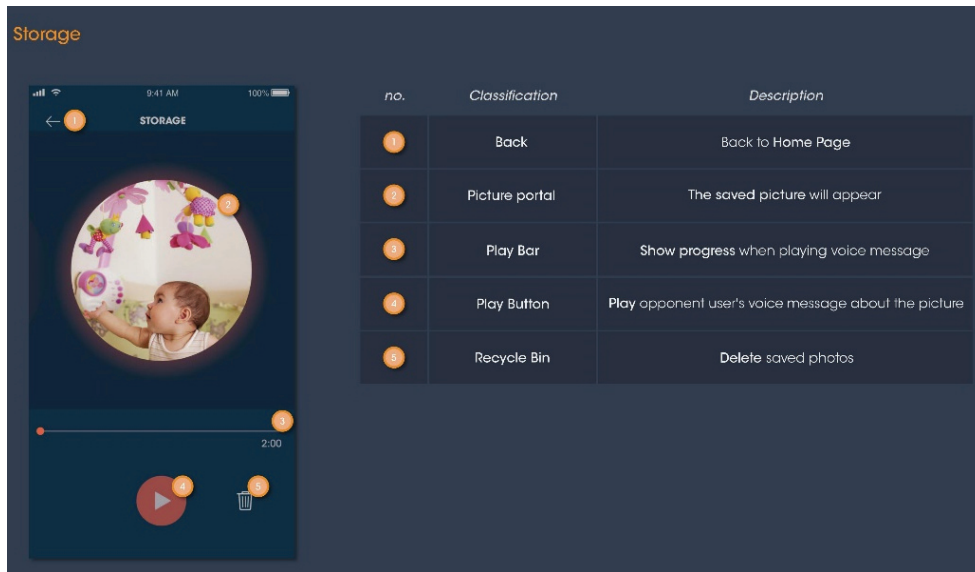


**Figure 12. UI detail of moving Adding Picture page**

When the user taps the plus icon in the lower center of the home page, the add picture page appears.

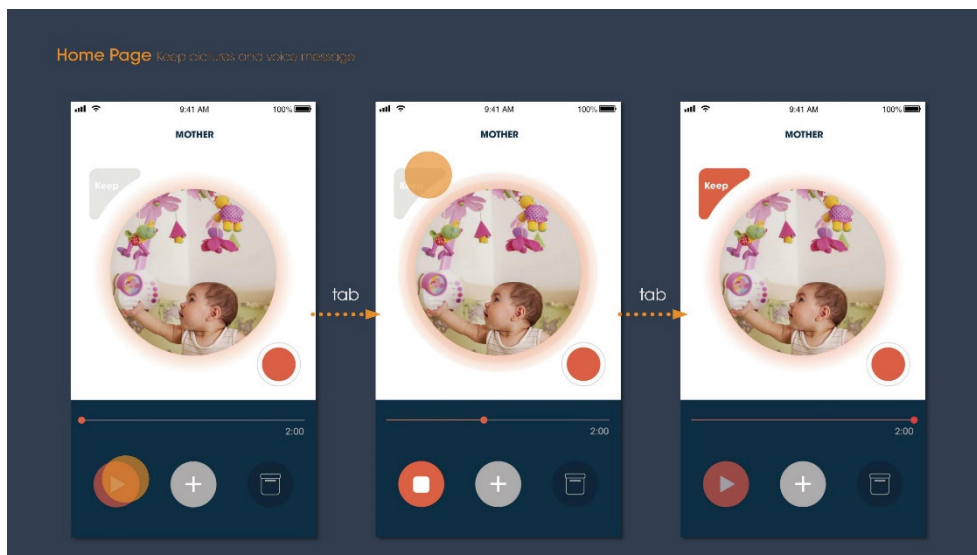
### ***Storage***

The storage page is a page where users can keep their favorite voice messages and pictures. As with physical products, the photos and voice messages that appear on the front page of the homepage disappear after a day. However, if the user wants to keep images and voice messages for a longer time, they can use the keep button to store them (Figure 13).



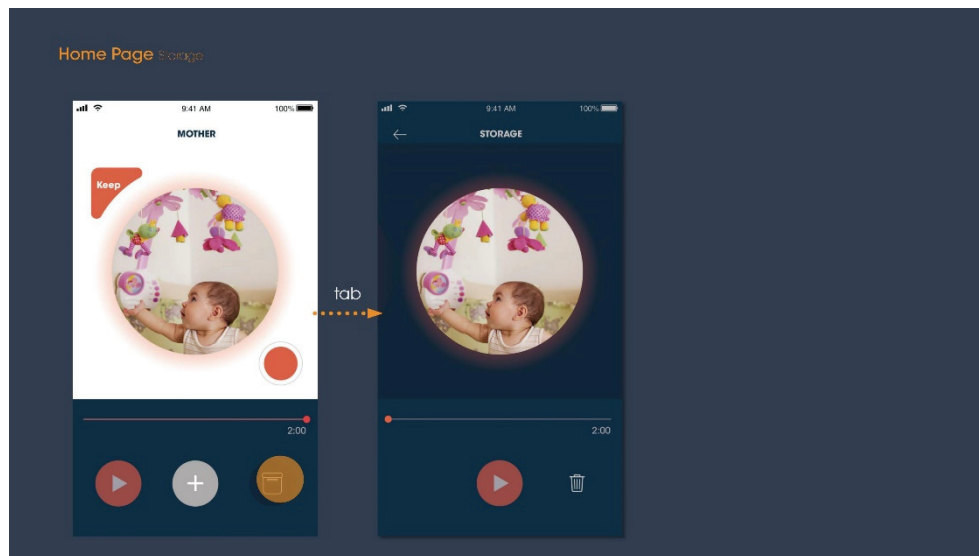
**Figure 13. UI detail of Storage page**

At the top of the storage page is a back icon that allows user to go back to the home page (#1 in Figure 13). The stored pictures are shown on the front and the play button and play bar are located at the bottom to replay the voice messages for the pictures (#3 and 4 in Figure 13). The stored data can also be deleted via the recycle bin button on the lower right (#5 in Figure 13).



**Figure 14. UI detail of keeping picture and voice message**

Users tap the keep button at the top left of the home page to save the image and voice message they want to keep. The color of the button will turn orange and the image will be saved on the storage page (Figure 14).

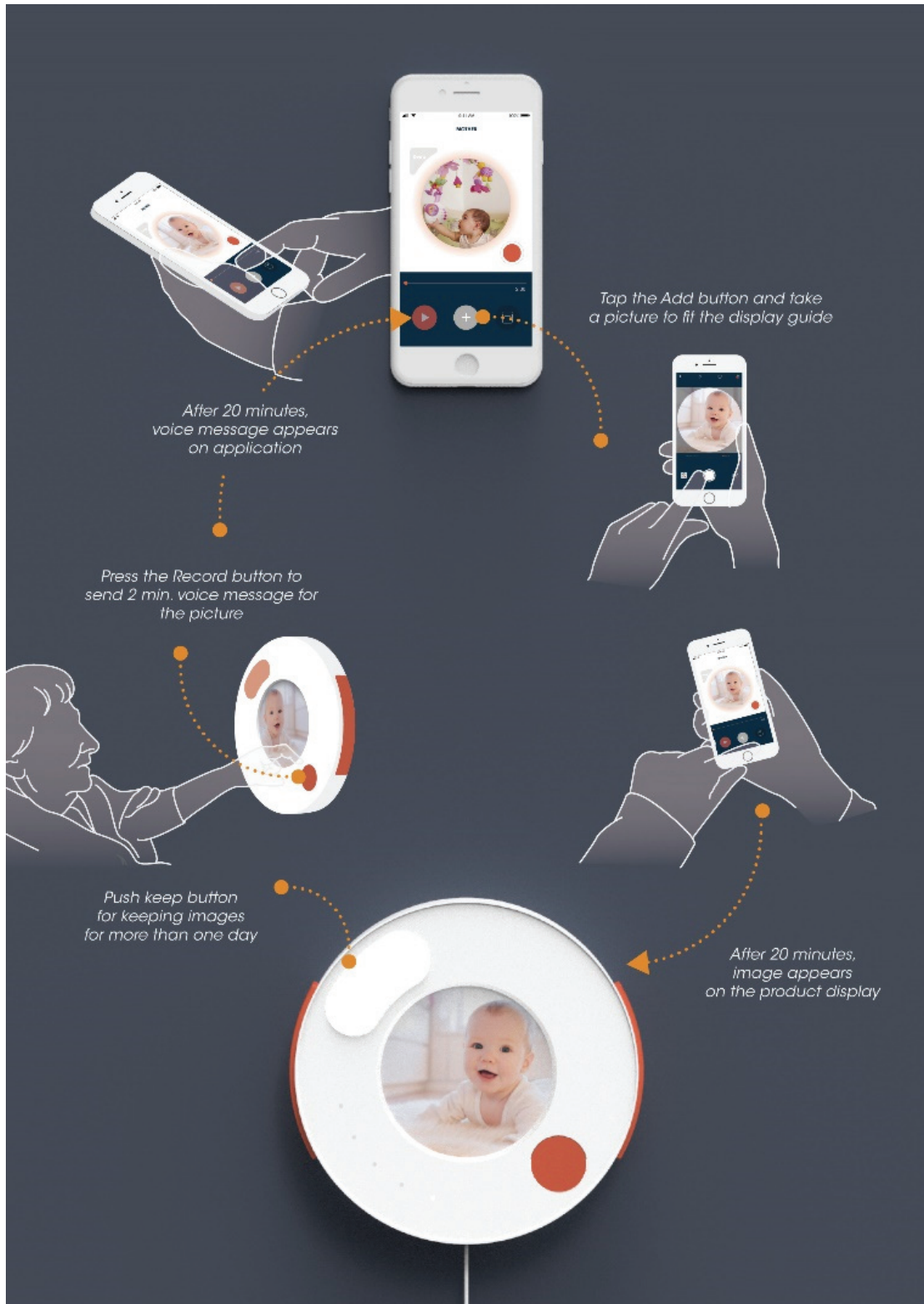


**Figure 15. UI detail of moving Storage page**

To appear photos of storage, tapping the Storage icon at the bottom right of the homepage will display the storage page (Figure 15). This page allows the user to check archived images and voice messages.

### **Product Scenario-of-Use**

PicCo's physical product component hangs on the wall of any domestic home environment. It's form and CMF (Color, Material, Finish) approach allow PicCo to stand out, but at the same time reference 'picture frame' or 'portal' design. PicCo will enrich the communication between the elderly living alone and their adult children or family members. This will help the elderly maintain social connections and help them organize their lives into richer interaction.



**Figure 16. Product scenario**

The product use scenario proceeds as illustrated in Figure 16. First, family members upload photos using the application. At this time, the user can use the photo guide to predict the range of the image that will appear on the display. After 20 minutes, the image appears on the physical product display. Elderly users can use the keep button to keep images shown on this physical product for more than one day. Also, if the user wants to leave a voice message for the image, they can start recording while holding the record button. By pressing and holding the record button, the indicator light gauge fills up to help the user know how much time is left in the recording. The maximum recording time is 2 minutes. If the user finishes recording before this time, they can stop by pressing the button. The voice message is then uploaded to the application after 20 minutes, and family members can check this message through the application.

### **3.3 SUMMARY**

The elderly and their adult children have different preferred interaction methods. However, existing products offer communication in only one way (one product or one application). This interferes with the continued use of the product. We provide the most familiar method for each target. For older people who are familiar with physical products, we offer more intuitive, physical interaction points. In addition, we continue to develop the product by providing an application for adult children who consider accessibility to be important. In addition, PicCo provides communication clues in an unobtrusive way to the daily lives of users by adding 20 minutes of delay to uploaded images and sounds. PicCo solves the social disconnect of the elderly living alone and provides them with links to their families. They will be able to exist unobtrusively in each other's lives in a way that is appropriate for them. This can be a way of further enriching communication between families and provide partial solution to help tackle issues around elderly loneliness and isolation when living geographically apart from family and loved ones.



## Chapter 4 Implementation

Based on the concept, we proceeded with the working prototyping process. To evaluate the usability of older users, we focused on hardware and software implementation of physical products.

### 4.1 HARDWARE IMPLEMENTATION

The internal structure was designed considering the existing 4:3 display utilization. In addition, a total of six holders were made to fix each part to the product. The total number of parts is 13, including brackets for fixing the product to the wall (Figure 17).

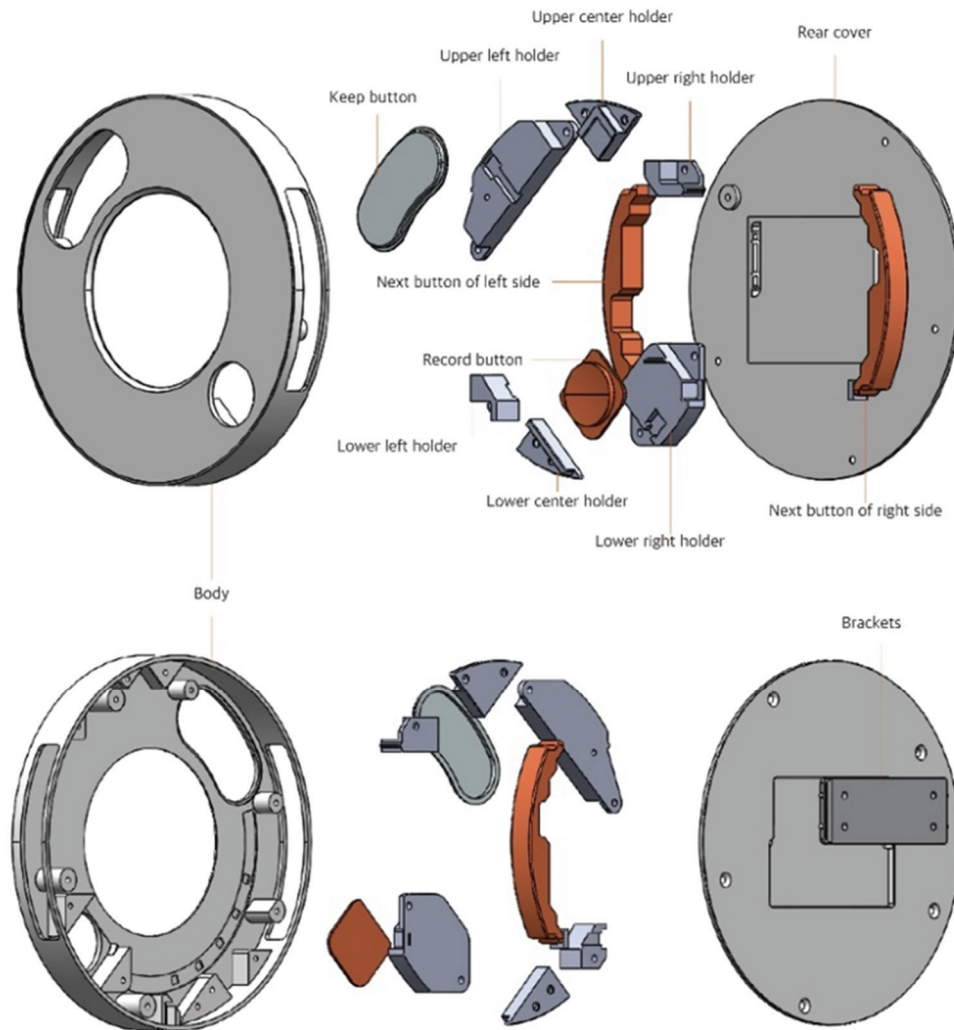
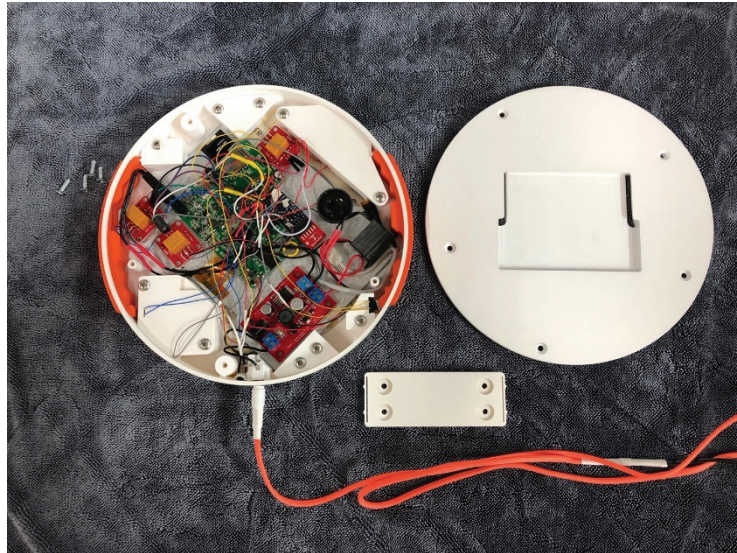


Figure 17. Working prototype components

Except the keep button, the twelve parts were made with ABS CNC. The Keep button was produced in milky acrylic CNC for light feedback and a rough surface produced with a sanding machine. In addition, for uniformity of design, the wires were covered with orange fabric (Figure 18).



**Figure 18. Working prototype internal form**

Through the material exploration of the Keep button, we have been able to understand how we can provide the user with clearer light feedback that matches the product. We found that it is not possible to reproduce the feedback of changing the color of the button through painting after ABS CNC. Instead, we changed the color of the buttons so that they could be more clearly perceived by elderly users (Figure 19).



**Figure 19. Keep button material exploring**

When the EL panel is off, it is shown as an ivory color button, and a bright orange color is displayed after the light is on using acrylic sanding.

## 4.2 SOFTWARE IMPLEMENTATION

Arduino was used for Software Implementation. Due to time and cost constraints, it was inevitable to utilize existing digital frame systems. Focused on three basic functions for usability evaluation, it was focused on storage function, recording function, and moving to next image function. The utilized parts are LED strap, EL panel, Arduino relay, and general toggle button.

### Next Button

The next button was implemented using a generic toggle button. In conjunction with the next button and the LED strip, we set pressing the next button to move one by one within each of the five light indicators, giving the user feedback on the image order. When the left next button is pressed, a light indicator moves to the left. Pressing the right next button, the light indicator moves to the right (Figure 20).



Figure 20. Implementation of next button

### Keep Button

A keep button was configured to be applied for each image. It was implemented to record whether the Keep button is pressed on each indicator. When the user presses the keep button, the EL(Electroluminescence) light is turned on to provide feedback to the user that the image has been

saved. Also, if the user presses the keep button once more to cancel the save, the EL panel is turned off to let the user know that the image is not stored. This is implemented by turning off the relay connected to the EL panel when the toggle button is pressed, and the relay is connected (Figure 21).



**Figure 21. Implementation of keep button**

### **Record Button**

The toggle button on the record button is related with the LED strap. When the user presses and holds the record button, the five light indicators are slowly turned on one by one. This indicator informs the remaining recording time to users. When the user stops pressing the button in the middle, it returns to its original state. On the other hand, when all five indicators are turned on, they return to their original state regardless of whether the button is pressed (Figure 22).



**Figure 22. Implementation of record button**

### **4.3 SUMMARY**

We wanted to identify the feasibility of the concept through hardware and software implementation, and to create a working prototype and use it for usability evaluation. Thus, a working prototype was created through 3D CAD modeling using SolidWorks and technology implementation using Arduino. The working prototype helped us to discover more usability issues through usability evaluation.

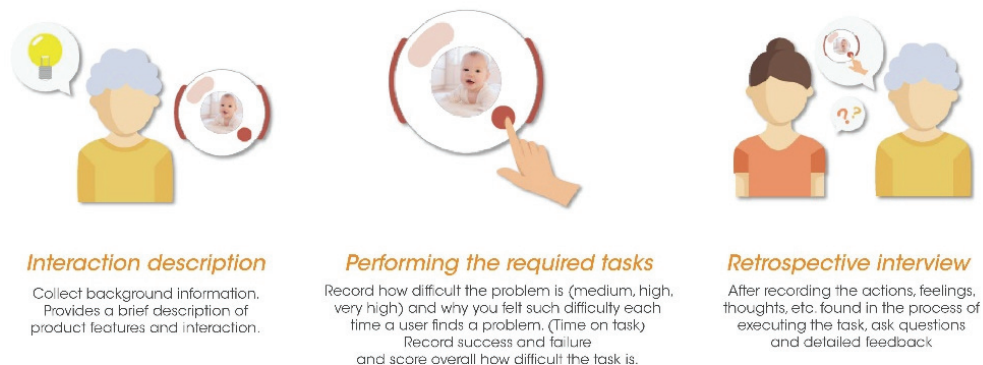
## Chapter 5

# Testing and Refinement

### 5.1 TESTING (USABILITY EVALUATION)

#### Purpose of evaluation

We conducted a usability evaluation using a working prototype to evaluate the viability of the PicCo product concept. According to Nielsen (2000), in the case of a product, if the usability evaluation is carried out through five participants, it is possible to identify 85% of usability problems. Therefore, we evaluated five elderly people aged 65 and over (Avg. age of 76.8). We also designed the evaluation focusing on the understanding the product 's physical interaction. To achieve this, we utilized the existing usability evaluation guide, but modified it to consider some limitations of our target user characteristics (Nielsen, 1994). The evaluations were conducted one by one and primarily collected information on age, gender, and type of housing (Figure 23).



**Figure 23. Process of usability evaluation**

#### Participants

We collected information on their gender, age, and main communication tool / method for the five participants (Table 3).

**Table 3. Usability evaluation participant information**

| <b>Participant code</b> | <b>Gender</b> | <b>Age</b> | <b>Profile</b>   | <b>Main communication tool/method</b>    |
|-------------------------|---------------|------------|--|--|
| G01                     | Female        | 82         | - livings alone<br>- 4 immediate family members,<br>- low technology level             | Voice call,                              |
| G02                     | Male          | 72         | - living alone<br>- 4 immediate family members,<br>- low-intermediate technology level | Voice call,<br>Text message              |
| G03                     | Female        | 70         | - living alone<br>- 5 immediate family members,<br>- low-intermediate technology level | Voice call,<br>Video call<br>(sometimes) |
| G04                     | Female        | 81         | - living alone,<br>- 3 immediate family members,<br>- low technology level             | Voice call                               |
| G05                     | Female        | 79         | - living alone<br>- 5 immediate family members,<br>- low technology level              | Voice call                               |

We interviewed the participants to identify existing communication approaches with family members. Except for G02 and G03, participants answered that they communicated with their family using a voice call only. G02 and G03 used additionally text messages and videophone calls, albeit less frequently than voice calls.

### **Usability Evaluation Progress**

The usability evaluation progressed in three stages. First, we explained our concept to the participants. We then presented a description of the concept and the context in which it is to be used. We then naturally gathered information about their preferred types of communication. We also used the functional prototype to explain and demonstrate each interaction to the participants. The

descriptions were repeated until they were fully understood. After confirming their understanding, in the study's second step, we gave participants a task. The task consists of four steps in total.

First, the participants checked the first to the last photos. Then they saved their favorite image among five pictures using the keep button. Third, the participants recorded his or her impression on the second favorite image. Finally, subjects were asked to recall the photos saved in the second step and un-save them. We asked participants to speak their thoughts out loud during the task (Figure 24).



**Figure 24. Taking usability evaluation task**

After the completion of the task, we conducted a system usability scale questionnaire to assess overall feelings about the system after use. This questionnaire is based on the System Usability Scale (SUS), which was developed by Brooke (1996). The SUS questionnaire was translated into Korean before use. In addition, the facilitator provided explanations and examples for each item considering the age range of the target participants (Figure 25).



나이 \_\_\_\_\_ 성별 ( 남자 , 여자 )

1. 이 제품을 자주 사용할 것 같습니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

6. 이 제품은 지나치게 기능과 작동이 복잡하다고 생각합니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

2. 불필요하게 복잡하다고 느낀 기능이 있습니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

7. 대부분의 사람들이 이 제품의 사용법을 매우 빨리 익힐 수 있을 것이라고 생각합니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

3. 나는 이 제품이 사용하기 쉽다고 생각하였습니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

8. 이 제품의 사용법은 매우 번거롭습니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

4. 이 제품을 사용하려면 기술자의 지원이 필요하다고 생각합니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

9. 이 제품을 사용하는 데에 있어 확신을 느꼈습니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

5. 이 제품은 다양한 기능이 잘 합쳐져 있는 것 같다고 생각합니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

10. 나는 이 제품을 사용하기 위해 많은 것을 익혀야 할 필요가 있다고 느낍니다.

| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|-----------|--------|--------|-----|---------|
|           |        |        |     |         |

Figure 25. SUS questionnaire

## 5.2 FINDINGS

### Usability Problems

We were able to identify some usability issues through the usability test. Participants commonly said that it would take a while to learn the button function. The function itself is simple and easy to understand, but it takes time to match the position of the button. Participants responded that they needed a signifier on the button (e.g., a word indicating the function). Particularly, participants G01, G03, G04, and G05 felt confused about the direction of the side button compared to the save and the record buttons. Also, they did not match the direction of the next button with the light indicator. Every participant thought that each function was not complicated, and it was fairly simple to use, but said that they felt difficulty around interaction and distinction of the button that executes the function. An additional discovery was that when participants used the record button, they were confused by the light indicator being turned off altogether. Because of this confusion, they knew that they had to press and hold the record button, but they were embarrassed and said they could not hold it well. Because the wrong feedback caused confusion to the participants, we were able to identify a need to modify the feedback on the record button. Table 4 outlines participant responses and their classification into ‘Usability response’ categories.

**Table 4. Usability response through interview**

| Usability insight                                     | Interview response  |
|---|---|
| <p>Button function is confusing</p>                   | <p>G01 "How can you go to the next?"</p> <p>G01 "It will take some time to remember the function of each button, about a month."</p> <p>G01 "This concept is good, but it's too difficult to memorize button functions"</p> <p>G02 "I want that each button has different colored or write function or button name on the button."</p> <p>G03 "I do not know which button to press to move to the next."</p> <p>G03 "It's hard for elderly people like me to quickly memorize something. I want the buttons to be simplified."</p> <p>G03 "I think it's easy to memorize the save button or record button for a week, but the Next button will take a long time to match to the direction."</p> <p>G04 "What was this button? I forgot that"</p> <p>G04 "I do not know what this button does. I want you to write it down."</p> <p>G04 "I guess I'll probably be able to memorize the button if someone keeps on teaching me."</p> <p>G05 "I forgot how to save it, was this round button?"</p> <p>G05 "Although this button is easy for young people to identify, most older people will probably take a long time to memorize the function of the button."</p> <p>G05 "I think the Next button will be able to distinguish if you change to different colors on each sides"</p> |
| <p>The feedback of the record button is not clear</p> | <p>G01 "When I pressed the button, I was wondering why this light turn off."</p> <p>G02 "I was very surprised when this indicator was turned off when the button was pressed."</p> <p>G03 "When I pressed the button to record it, the light indicator light turns off and I think the product was broken"</p> <p>G04 "I do not know when I press this button that I have to keep pressing it or just press it once."</p>   |
| <p>Function complexity</p>                            | <p>G01 "In fact, it seems to be much easier even if only one function is right."</p> <p>G03 "The function itself is not complicated, but the button does not match well"</p> <p>G04 "It took me a while to understand what it was."</p>   |

## System Usability Scale Result

The System Usability Scale (SUS) yielded a single score that comprehensively represents the overall usefulness of the system. Individual scores for each item are meaningless. We can calculate the SUS score by adding up the score contribution of each item. For items 1, 3, 5, 7, and 9, the score contribution is the value of each scale score minus 1. On the other hand, for items 2, 4, 8, and 10, the contribution is 5 minus the score contribution is the value of each scale. The SUS score is achieved through a sum of all the contribution values for each item, multiplying by 2.5. When the SUS average score was calculated using the SUS calculation method, the average SUS score of the five participants was identified as 40.5. The maximum SUS score was 55, with a lowest of 20. Each item has a score contribution from 0 to 4 (Brooke, 1996) (Figure 26).

나이 72      성별 (남자, 여자)

1. 이 제품을 자주 사용할 것 같습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

2. 불필요하게 복잡하다고 느낀 기능이 있습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

3. 나는 이 제품이 사용하기 쉽고 생각하였습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

4. 이 제품을 사용하려면 기술자의 지원이 필요하다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

5. 이 제품은 다양한 기능이 잘 합쳐져 있는 것 같다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

6. 이 제품은 지나치게 기능과 작동이 복잡하다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

7. 대부분의 사람들이 이 제품의 사용법을 매우 빨리 익힐 수 있을 것이라고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

8. 이 제품의 사용법은 매우 번거롭습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

9. 이 제품을 사용하는 데에 있어 확신을 느꼈습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

10. 나는 이 제품을 사용하기 위해 많은 것을 익혀야 할 필요가 있다고 느낍니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

Figure 26. example of SUS questionnaire result

The two lowest SUS scores among 5 participants were over 80 years of age (G01 and G04) (Table 5). In addition, these two participants did not have any other communication method other than voice call. Other participants were using simple text messages or other communication methods with voice call. Depending on the technology acceptance, we could see that this concept is still causing some confusion for participants.

**Table 5. System usability scale (SUS) score result**

| Question  | Participant response score |             |           |           |           |
|---|----------------------------|-------------|-----------|-----------|-----------|
|   | G01                        | G02         | G03       | G04       | G05       |
| I think that I would like to use this system frequently                                   | 4                          | 2           | 2         | 3         | 2         |
| I found the system unnecessarily complex  | 0                          | 1           | 3         | 1         | 2         |
| I thought the system was easy to use  | 0                          | 2           | 1         | 1         | 3         |
| I think that I would need the support of a technical person to be able to use this system | 0                          | 3           | 3         | 1         | 2         |
| I found the various functions in this system were well integrated                         | 2                          | 2           | 1         | 2         | 2         |
| I thought there was too much inconsistency in this system                                 | 0                          | 3           | 1         | 1         | 1         |
| I would imagine that most people would learn to use this system very quickly              | 0                          | 3           | 2         | 0         | 1         |
| I found the system very cumbersome to use   | 1                          | 3           | 3         | 1         | 2         |
| I felt very confident using the system  | 1                          | 1           | 2         | 0         | 3         |
| I needed to learn a lot of things before I could get going with this system               | 0                          | 1           | 4         | 0         | 2         |
| <b>Total Score</b>  | <b>8</b>                   | <b>21</b>   | <b>22</b> | <b>10</b> | <b>20</b> |
| <b>SUS Score (Total score * 2.5)</b>  | <b>20</b>                  | <b>52.5</b> | <b>55</b> | <b>25</b> | <b>50</b> |

## Retrospective Interview

We were able to confirm the feedback and utility of various products through retrospective interview (Table 6).

**Table 6. Product utility response through interview**

| Product utility insight | Interview response  |
|-------------------------|---|
| Product Accessibility   | <p>G01 "This is not unfamiliar to me because it reminds me of a picture frame at home."</p> <p>G01 "There were some difficult parts, but I think it will be useful after I learn the function of this product."</p> <p>G02 "It reminds me of a picture frame in my house"</p> <p>G03 "Compared to smart phones with complex functions, it seems relatively easy to use because it doesn't need high functional understanding."</p> <p>G03 "Video chatting with my smartphone is too difficult for me as an elderly person. However, this product will be more comfortable to use if I become familiar with some buttons."</p> <p>G05 "I think it would be easy to be recognized if I put this on the wall."</p>                     |
| Product Availability    | <p>G01 "I want to exchange images with my daughter who lives in USA."</p> <p>G01 "I am always curious about the news of a child living far away but there was no way out of the phone. This product looks very effective because it shows the image."</p> <p>G03 "I occasionally contact my son with a video call. But if there's an easier way than this, I'm going to be actively involved."</p> <p>G04 "When I contacted my daughter who lives far away only by voice call, I felt a lot of limitations."</p> <p>G04 "It was too good to expand the contact material that was limited to voice only."</p> <p>G05 "I have been wanting to be able to contact my family more actively. This product might be able to help it."</p> |

In fact, most participants had difficulty with existing contact tools and wanted to communicate with their family through various contents. Despite some of the usability issues mentioned above, participants replied that the PicCo concept was more familiar and easier to understand than the existing tools. Based on improvements in usability issues and familiarity with the interactions that make up the product, participants responded that the design would be more accessible and hoped that it would improve the quality of communication with families over distance through richer

communication and content. Also, interestingly, participants said that the shape of the product hang on the wall reminded them of a photo frame they were already using. These factors helped make participants feel more familiar with the product.

In addition, we learned from the interviews that the product's installation on the wall, which is an easy-to-see location, helped the participants to more easily recognize and use the product.

### **5.3 INSIGHTS**

As a result, we were able to derive the necessary elements of the physical interaction for the elderly user. Through interviews and tasks, we found that participants needed well-organized and clear structure of interaction with simplified interaction element. We have simplified the interaction components with three functions and hoped that they could be matched to functions by the position and shape of the buttons. However, some participants (G01, G03, G04 and G05) cannot connect buttons and functions. We found out the reason through the retrospective Interview. G01 knew that the position of the next button was consistent with the function, but she did not have the confidence to match the function of the button because there was no real direct visual indication. Also in case of G04, she responded that although the form of the record button seemed to be functionally consistent, she was not sure if she would be able to match again in the next use without someone's explanation. G03 and G05 wanted a direct and intuitive visual description on each button. In particular, G03 responded that they wanted the direction to be clearly distinguished by color or text. Thus, we expect that in the case of physical interactions for the elderly, intuitive and direct visual instruction acts as a key to connecting functions and elements at the future use as well as initial use. We also found through interviews that familiar forms (such as picture frames) and familiar interactions (such as physical buttons) can enhance participants' psychological accessibility and encourage continued use. G01 and G04 responded that there is little resistance to installing the product because it looks like a frame when the product is hung on the wall. In addition, G02 said that when using the product for the first time, it was relatively familiar with the product because it was an interaction using a physical button rather than a touch screen like a smart phone. Some participants (G01, G02, and G04) said that this familiarity not only helps to familiarize the product relatively easily, but also helps to keep it going. Therefore, through familiar interaction methods or forms, we can derive the possibility that enhance the ongoing use of interactions for elderly users and in part solve the rejection of new products that elderly have.

### **5.4 REFINEMENT (FURTHER REFINEMENT POINT)**

We felt the need to simplify our concept through usability evaluation. In fact, we realized that the concept was constructed using the physical button that the target user was familiar with. However, we

found that the interaction with the button could still feel complicated to the target user. We felt the need to simplify our concept through usability evaluation. In fact, we realized that the concept was constructed using the physical button that the target user was familiar with, but we found that the interaction with the button could still feel complicated to the target user. The idea of showing one image in a more effective way can be a more meaningful concept to the user than a way of showing several images. Or we can expect a way to convert the storage function to a physical form.

Interestingly, two participants over the age of 80 who had a low SUS score indicated that they would likely use this product frequently. As mentioned above, the communication methods of these two participants were limited to voice calls alone. Communicating through images and voice to them was interesting, especially for one participant. G01 hoped that this product could play an important role in communicating with a daughter living overseas. As such, all participants responded positively to the utility of the product concept. However, they responded that they hoped issues could be resolved related to some usability problems that caused confusion. Through future research, we expect that this concept will be useful enough for the target user if the function and interaction are further simplified and intuitively modified.

## **5.5 SUMMARY**

This chapter discussed the process and results of a usability evaluation. In fact, simple functions and interactions for younger generations with very high technology acceptance can be difficult and complicated for older users with low technology acceptance. This process was therefore essential and a very important step in developing the concept. Through this process, we were able to draw to a deeper understanding of the target user and further refinement points. In addition, we found the importance of providing enough time and explanations for participants in high age groups during the evaluation process to understand the concept. We took the time to give them more explanation and guidance than text, and this time was another opportunity to be provided a deeper understanding of the user. During further interviews, participants provided us with very meaningful feedback. They have limitations in how to communicate with families who live far away. In reality, they were feeling that way, and existing products were providing only limited forms of solutions, such as physical pictures, letters, or voice call. Our concept is meaningful in that it provides communication of new material such as image and voice to the problem. Participants were of the opinion that it was possible to transfer the high technology interaction that had been done only through the application to the physical product.

## Chapter 6

# Discussion

In this chapter, we will address discussion points and the insights we have found. We also discuss implications for the PicCo design and future development possibilities. Finally, we proceed with the limitations of our research.

### 6.1 DISCUSSION

Through usability testing, we found several discussion points. Regarding PicCo's design concept, the participants responded positively, responding that they were likely to use this product frequently. At the same time, however, a usability problem of this product was also found. First, participants over the age of 80 had difficulty understanding each element of the product. Despite their familiarity with the physical buttons, the layout and structure of the product features were confusing to them, especially for the target age with low technology acceptance. The most frustrating feature participants felt was the next Button. Subjects had difficulty in matching the directionality and position of the buttons. The light indicator also did not provide enough feedback for users. They needed a visual description of the function in the button itself and hoped to get a hint for each button in color or text.

The user-study participants also appeared to have a number of difficulties in matching buttons and functions, rather than having difficulty with the function, they described the function of the design as clear and simple. Still, they needed simpler, more explicit functionality and hoped that the features and buttons that represented it would be more easily matched.

### 6.2 DESIGN IMPLICATION

As mentioned above, we found that participants over the age of 80 with the lowest SUS (System Usability Scale) scores, felt the need for this product. They felt difficulty in communication other than limited communication methods. Participants G01 and G04 said that current contact methods were at the high technology level and that G01 and G04 lacked the full potential to understand and use them with low technology acceptance. All participants needed time to get accustomed to the product, but after a thorough understanding they expected it to be a rich communication tool. For this reason, we think that the PicCo product has the potential to serve as a new communication tool between the elderly and their family, consistent with our project goals.



### **6.3 LESSONS LEARNED**

The most important aspect of our project was understanding the target user. Pre-concept desk research and targeted user interviews were employed to build understanding of the target audience for the concept. However, this process alone does not fully lead to completely understand of the user. Through user interviews and desk research, we attempted to understand the problems and needs of the elderly living alone as target users. Through this process, we explored familiar interaction methods, sensory elements, and usage processes for elderly people. Based on this information, we created a using process that is divided into three steps and a physical button that is familiar to them.

However, through practical usability evaluation, we found many usability challenges. In particular, the interactions that were intended to be simple processes may seem complicated and unnecessary for the actual target user and realizing that this process is essential for product development for the elderly. Although we have used familiar elements, the concept may give rise to confusion because of the process of the interaction structures. We found that rather than many functions, a concept that is focused on one interaction only could be more useful to the user.

### **6.4 LIMITATIONS**

There are some limitations to the usability evaluation of this study. We did not visit the users at home, rather conducted our usability study in a local care home for the elderly due to participants' privacy concerns and the resistance to home visits. Thus, an elderly center was used as the evaluation place for providing an environment similar to a relatively usage context. We also provided participants with the same picture to reduce the inter-experiment variability. This was intended to control the condition so that each participant can eliminate the variables of family intimacy and evaluate usability under the same conditions. However, adopting this approach meant removing much of the emotional response critical to the product concept.

Further studies are required to overcome these limitations. For example, further in field studies may reveal other challenges and opportunities when using PicCo in its actual use context (i.e. the elderly user's home). On the other hand, according to Kjeldskov et al's (2004) study, the evaluation in laboratory and field conditions is not significantly different. To respond to this concern, we attempted to simulate the home environment through the use of the elderly care center, hanging up the wall.

## Chapter 7

# Conclusion

### 7.1 RESEARCH FINDINGS

Through this study, we have provided a remote communication method between elderly users and their families, geographically separated from one another. We have identified the design's strengths and limitations through an iteration of user testing and validation. Through this approach, we were able to identify some usability challenges and opportunity for further design refinement. Target users need not only a simple interaction method, but also a functional structure that can be quickly understood, implemented in a visually recognizable form.

Our original research question aimed to explore the challenge of communicating between the elderly living alone and their geographically remote family members. We also wanted to find the most appropriate interaction / communication method within the particular context of Korea. The elderly living alone and their family communication was limited to voice calls. This is caused by differences in the method of communication between family members and the elderly. Younger generations with higher technology acceptance tended to prefer low accessible and less time-consuming method like text messages, SNS and social media platforms. In contrast, older generations with lower technology acceptance tended to use the most familiar methods of voice call and use physical methods like physical photos. Also, from the family's perspective, due to a lack of time, a simple process that was comfortable and unobtrusive to their everyday life was identified as desirable.

Based on these needs, we created the design concept: PicCo. Through a working prototype, usability was tested to explore the concept's suitability and viability for our target users. This enabled us to identify the feasibility of the concept and explore the points to be modified. We investigated a variety of solutions, such as simplifying the product interaction structure and making the function to physically methods (e.g. Printed out picture for saving) of the storage button. We also found that elderly users needed a more understandable, clear functional structures and more visual /direct signifiers than various functions.

### 7.2 EXPECTED CONTRIBUTION

While previous studies (Forghani et al., 2018) have attempted to provide solutions to different target users, our study suggests two different approaches to each based on a different understanding of the two target users. We present a new communication method with a physical IoT (Internet of Things) product rather than software-oriented elder communication solutions. Through interviews, desk research and usability evaluation results, we were able to further explore the factors (simplified,

structured interface) to consider when designing physical communication tools for older users. In this way, we were able to reinterpret the solution focused on one direction with the viewpoint of the product designer to broaden the direction and provide the opportunity to support various forms of elderly communication solutions.

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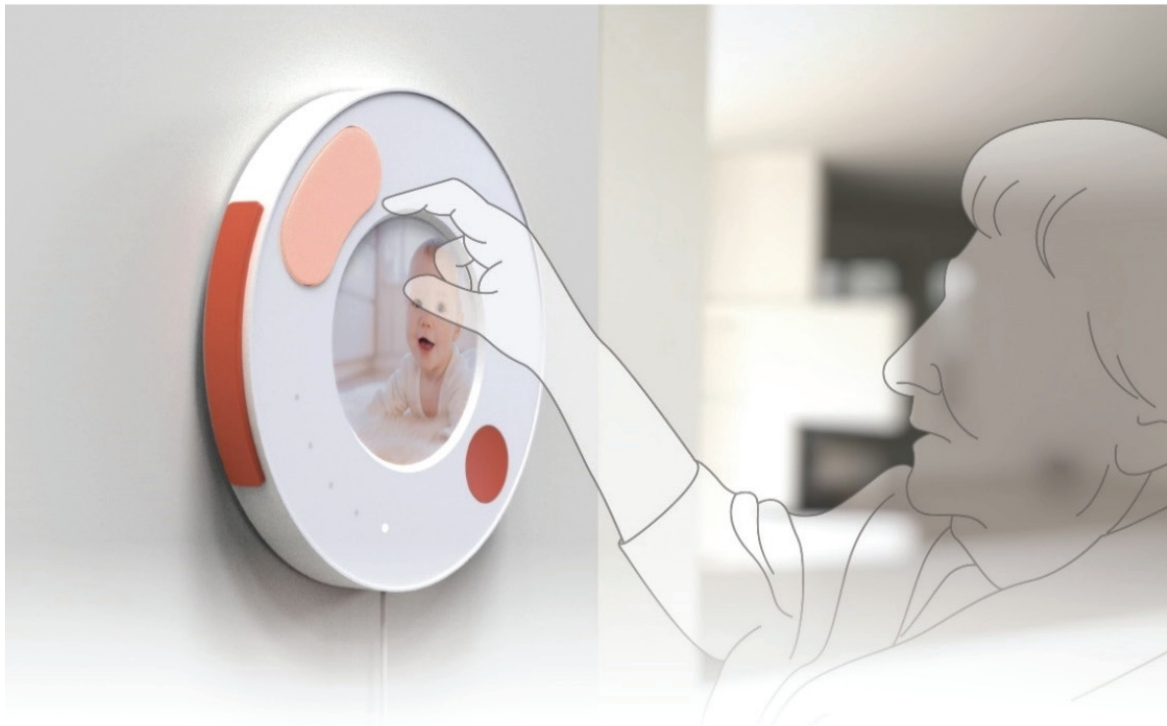
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## APPENDICES

### Appendix A PicCo Concept Image Board 01



## Appendix B PicCo Concept Image Board 02



### Silver generation challenges

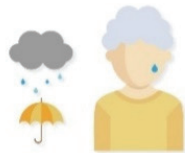
2017

The total elderly population



**133,6909**

The number of  
elderly living alone



**15%**

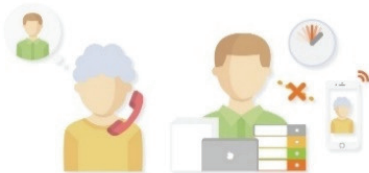
Elderly  
depression rate



**Social  
Disconnect**

Depression due to  
social disconnection

### Design problem



**Time poor**

Family challenged to find time to talk  
with elderly people



**Incompatible media  
of communication**

Elderly Unfamiliar with modern,  
digital communication (i.e. social media)

## Appendix C PicCo Concept Image Board 03

# Interaction

*Unobtrusive way to daily life*

*By providing a 20-minute delay in uploading photos and voice messages, PicCo does not interfere with everyday life. We provide communication clues through photos and voice messages between the elderly living alone and their families.*





## Appendix D PicCo Concept Image Board 04

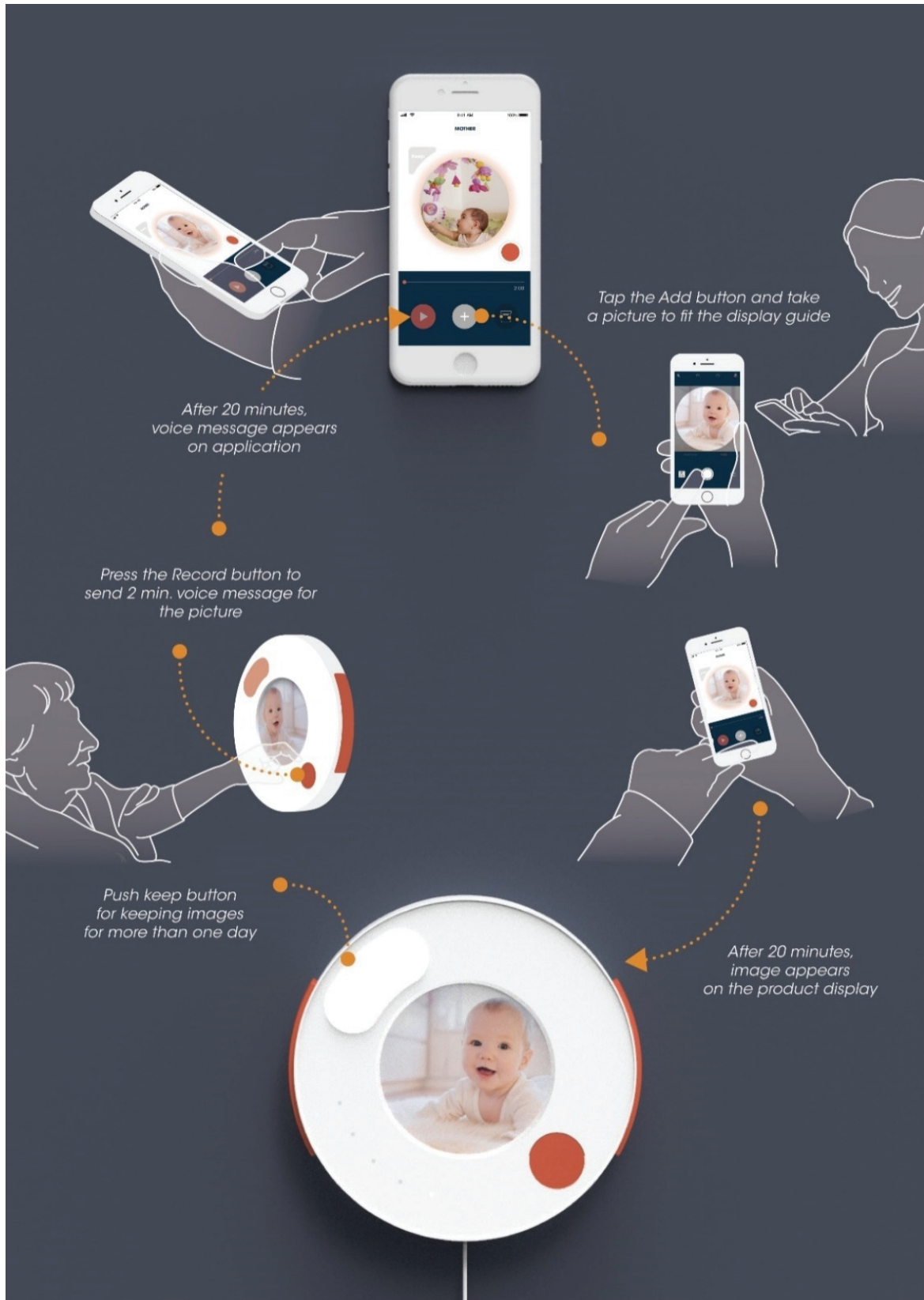
# Application

*For families who live far away*

*Through the application, family members can easily transfer photos to their mother or grandmother. Users can also receive voice messages as answers to the photos they have sent.*



## Appendix E PicCo Concept Image Board 05



## Appendix F System Usability Scale Result of G01

나이 22 성별 (남자, 여자) (여자)

- 이 제품을 자주 사용할 것 같습니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |
- 불필요하게 복잡하다고 느낀 기능이 있습니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |
- 나는 이 제품이 사용하기 쉽다고 생각하였습니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |
- 이 제품을 사용하려면 기술자의 지원이 필요하다고 생각합니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |
- 이 제품은 다양한 기능이 잘 합쳐져 있는 것 같다고 생각합니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

6. 이 제품은 지나치게 기능과 작동이 복잡하다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

7. 대부분의 사람들이 이 제품의 사용법을 매우 빨리 익힐 수 있을 것이라고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

8. 이 제품의 사용법은 매우 번거롭습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

9. 이 제품을 사용하는 데에 있어 확신을 느꼈습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

10. 나는 이 제품을 사용하기 위해 많은 것을 익혀야 할 필요가 있다고 느낍니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

total = 8  
SUS = 20

## Appendix G System Usability Scale Result of G02

나이 72 성별 (남자, 여자) (남자)

- 이 제품을 자주 사용할 것 같습니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |
- 불필요하게 복잡하다고 느낀 기능이 있습니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |
- 나는 이 제품이 사용하기 쉽다고 생각하였습니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |
- 이 제품을 사용하려면 기술자의 지원이 필요하다고 생각합니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |
- 이 제품은 다양한 기능이 잘 합쳐져 있는 것 같다고 생각합니다.
 

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

6. 이 제품은 지나치게 기능과 작동이 복잡하다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

7. 대부분의 사람들이 이 제품의 사용법을 매우 빨리 익힐 수 있을 것이라고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

8. 이 제품의 사용법은 매우 번거롭습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

9. 이 제품을 사용하는 데에 있어 확신을 느꼈습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

10. 나는 이 제품을 사용하기 위해 많은 것을 익혀야 할 필요가 있다고 느낍니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

total = 21  
SUS = 52.5

## Appendix H System Usability Scale Result of G03

나이 40 성별 ( 남자 (여) )

1. 이 제품을 자주 사용할 것 같습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

2. 불필요하게 복잡하다고 느낀 기능이 있습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

3. 나는 이 제품이 사용하기 쉽다고 생각하였습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

4. 이 제품을 사용하려면 기술자의 지원이 필요하다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

5. 이 제품은 다양한 기능이 잘 합쳐져 있는 것 같다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

6. 이 제품은 지나치게 기능과 작동이 불일치 한다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

7. 대부분의 사람들이 이 제품의 사용법을 매우 빨리 익힐 수 있을 것이라고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

8. 이 제품의 사용법은 매우 번거롭습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

9. 이 제품을 사용하는 데에 있어 확신을 느꼈습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

10. 나는 이 제품을 사용하기 위해 많은 것을 익혀야 할 필요가 있다고 느낀다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

total = 22  
sus = 55

## Appendix I System Usability Scale Result of G04

나이 37 성별 ( 남자 (여) )

1. 이 제품을 자주 사용할 것 같습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

2. 불필요하게 복잡하다고 느낀 기능이 있습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

3. 나는 이 제품이 사용하기 쉽다고 생각하였습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

4. 이 제품을 사용하려면 기술자의 지원이 필요하다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

5. 이 제품은 다양한 기능이 잘 합쳐져 있는 것 같다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

6. 이 제품은 지나치게 기능과 작동이 불일치 한다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

7. 대부분의 사람들이 이 제품의 사용법을 매우 빨리 익힐 수 있을 것이라고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

8. 이 제품의 사용법은 매우 번거롭습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

9. 이 제품을 사용하는 데에 있어 확신을 느꼈습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 0         | 1      | 2      | 3   | 4       |

10. 나는 이 제품을 사용하기 위해 많은 것을 익혀야 할 필요가 있다고 느낀다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
| 4         | 3      | 2      | 1   | 0       |

total = 10  
sus = 25

## Appendix J System Usability Scale Result of G05

나이 29 성별 ( 남자 / 여자 )

1. 이 제품을 자주 사용할 것 같습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        | 0      |     |         |

2. 불필요하게 복잡하다고 느낀 기능이 있습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        | 0      |     |         |

3. 나는 이 제품이 사용하기 힘들다고 생각하였습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        |        | 0   |         |

4. 이 제품을 사용하려면 기술자의 지원이 필요하다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        | 0      |     |         |

5. 이 제품은 다양한 기능이 잘 합쳐져 있는 것 같다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        | 0      |     |         |

6. 이 제품은 지나치게 기능과 작동이 복잡하다고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        |        | 0   |         |

7. 대부분의 사람들이 이 제품의 사용법을 매우 빨리 익힐 수 있을 것이라고 생각합니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           | 0      |        |     |         |

8. 이 제품의 사용법은 매우 번거롭습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        |        | 0   |         |

9. 이 제품을 사용하는 데에 많이 확신을 느꼈습니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        |        | 0   |         |

10. 나는 이 제품을 사용하기 위해 많은 것을 익히야 할 필요가 있다고 느낍니다.

|           |        |        |     |         |
|-----------|--------|--------|-----|---------|
| 1         | 2      | 3      | 4   | 5       |
| 전혀 그렇지 않다 | 그렇지 않다 | 그저 그렇다 | 그렇다 | 완전히 그렇다 |
|           |        | 0      |     |         |

다려해사 x 2.5  
 total score = 20  
 SUS score = 50

## ACKNOWLEDGEMENT

지도 교수님 이신 제임스 셸프 교수님께 감사드립니다. 제가 어려움을 겪을 때 마다 교수님께서 아낌없이 지도해주시고 응원 해 주셔서 무사히 석사 졸업을 할 수 있었습니다. 힘든 시기에 저를 받아 주셔서 정말 감사하며 믿고 지켜 봐주셔서 큰 힘이 되었습니다. 교수 연구에 대한 많은 조언과 격려를 해준 박영우 교수님께도 진심으로 감사드립니다. 교수님께서 주신 조언들이 많은 도움이 되었습니다. 제가 보지 못한 부분까지 놓치지 않고 지적해주시고 도움을 주셔서 제가 무사히 연구를 마칠 수 있었습니다. 연구 뿐만 아니라 진로에 대한 조언과 도움을 아끼지 않으신 이희승 교수님께 정말 감사하다는 말씀 전하고 싶습니다. 10년 뒤에 제가 어떤 사람이 되어야 할지, 어떤 일을 해야 할지 사춘기 청소년처럼 고민하던 제게 교수님의 조언은 앞으로 나아가는 힘이 되었습니다.

언제나 도움을 아끼지 않으신 육기철 선생님께 진심으로 감사 드립니다. 선생님이 있었기에 저희가 언제나 발전할 수 있었으며 늦은 시간까지도 나서서 도와주신 선생님께서 계셨기에 저희가 무사히 모든 과정을 마칠 수 있었습니다. 어려운 부탁도 학생들을 위해서라면 기꺼이 해결해 주셨던 항상 밝은 모습의 김진경 선생님, 정말 감사합니다. 사고도 많이 치고 번거로운 일들을 많이 만들어 많이 죄송하고 선생님 덕분에 졸업한다는 말이 과언이 아닐 정도로 큰 힘이 되었습니다. 또한, 학생들을 위해 항상 힘써 주시는 김효진 선생님, 강우정 선생님, 임채정 선생님을 비롯한 모든 행정실 선생님들께도 진심으로 감사하고 죄송하다는 말씀 전합니다.

결에서 힘이 되어준 CDE 17학번 동기들에게도 감사합니다. 특히 함께 동고동락하며 다양한 경험을 함께 나눌 수 있었던 원도 오빠, 상진 오빠, 경진 언니, 한별이에게 진심으로 고맙다는 말 전합니다. 덕분에 힘들 수 있었던 석사 생활이 즐겁고 값진 경험들로 가득합니다. 덕분에 성장했고, 즐거웠고, 힘이 되었고, 행복했습니다. 항상 제 시야를 넓혀주고 스스로 한걸음 성장할 수 있도록 도와준 가이 언니, 고맙습니다. 언니 덕에 나는 더 다양한 것들을 돌아볼 수 있었으며 힘든 순간에 언니가 건네 준 위로가 내가 멈추지 않을 수 있었던 힘이 되었습니다. 작년 내내 같이 많은 일을 했던 가을에게는 미안하고 고맙다는 말을 전하고 싶습니다. 막내임에도 불구하고 어른스럽고 밝은 모습으로 항상 큰 자극이 되었습니다. 이번 해 같이 프로젝트를 진행해준 동훈 오빠에게도 고맙습니다. 나서서 굵은일을 맡아 주시고 도움이 필요할 때마다 정말 많은 도움 아낌없이 주셔서 매번 감사하고 죄송했습니다. 가장 친한 친구이자 동료인 영철 오빠, 언제나 한결같은 모습으로 연구와 진로에 든든한 지원군이 되어주었고 힘들 때마다 웃을 수 있는 원천이 되어주었습니다. 고맙다는 말로 부족하지만, 앞으로 남아 있는 날 들에서 그 고마움을 모두 전해볼까 합니다. 마지막으로, 학부, 석사 통틀어 7년 동안 사고도 많이 치고 수없이 속도 썩인 큰딸에게 언제나 한결같은 믿음과 사랑을 주는 부모님과 철없는 누나에게 아낌없이 주는 동생 강훈이에게 고맙다는 말 전합니다. 힘들 때마다, '우리는 언제나 네 편이다'는 말 한마디가 제게 큰 힘이었습니다. 항상 제가 가진 생각들을 함께 고민해주고 언제나 내 편이 되어준 가족들이 있었기에 외롭지 않게 제 길을 걸을 수 있습니다.

무사히 성장하자는 마음 하나로 시작된 석사는 다행히 그 목표를 아주 조금은 이루어 내지 않았나 생각해 봅니다. 이 모든 결과가 저 혼자만의 것이 아니라는 것을 알고 있습니다. 그렇기에 더 성장하고 발전하겠습니다. 옳은 일에 힘쓰겠습니다.

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## PicCo: Improved Communication between Elderly People & Geographically Remote Family Members through IoT Design

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This book is based on my Master Graduation Project, but *not* an official publication.  
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