The Use of Conversational Interfaces in Long Term Patient Care

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Declaration

I, L.A.S.M. Gunathilaka, 2015/IS/027 hereby certify that this dissertation entitled The Use of Conversational Interfaces in Long Term Patient Care is entirely my own work and it has never been submitted nor is currently been submitted for any other degree.

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I, W. V. Welgama, certify that I supervised this dissertation entitled The Use of Conversational Interfaces in Long Term Patient Care conducted by L.A.S.M. Gunathilaka, W.A.U.S. Weerasinghe and I.N. Wickramasinghe in partial fulfillment of the requirements for the degree of Bachelor of Science Honours in Information Systems.

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Abstract

Communication plays a significant role in human life. To fulfill the different requirements people use many communication methods. After learning their mother tongue they use native or foreign languages to communicate. People use different communication methods such as verbal, written, visual, paralanguage and other methods. However, people with disabilities face many problems when communicating with others. Even the patients with long term illnesses who could not complete their work alone expect others to listen to them. By the way, it is a necessity to have a caretaker to take care of the long term patients.

With the increasing number of the elderly and disable people, it is essential to use the technology to fulfill their needs and make them more independent. In most of the countries, they spend a more independent life thanks to technology and a comfortable lifestyle. In Sri Lanka, the elderly people get the assistance of a caretaker, since they are not very familiar with the technology and due to language barriers.

The machines emulate conversations with humans through conversational interfaces. Mainly we can identify chatbot as a main conversational interface where it's available on-screen and as a voice assistant. Since the voice integrated personal assistance is more fitting to the patient care domain, the thesis presents the observations done with the long term patients and the elders on their ability to communicate voice integrated personal assistance. The research is conducted using the design science research methodology to understand the current problem in society. The research is initiated with the motivation to facilitate the communication and psychological requirements of long term patients. For that, researchers conducted a review analysis on voice integrated personal assistance and the use of it in the long term patients and elderly people. Then the interview is conducted to identify the requirements of the elderly long term patients. By the results of the review analysis and the interview process, we prioritized the communication needs of them. Using the voice integrated personal assistance the proof of concept was developed for the identified needs. The proposed proof of concept is used to evaluate it on the elderly long term patients by mainly considering requirements such as loneliness, exercise tracking, and games.

The Developed solution quantitatively evaluated by elderly long term patients mainly under five criteria such as google home device, mind game, bedridden exercises, talking companion and overall conclusion. Most of them had a positive opinion to embrace the new experience while few of them had language issues due to the accent. In the analysis of overall satisfaction, more than 90% had total satisfaction of 0.75 or more which shows higher satisfaction. Elderly patients believe the device improves their independence and helps them to spend some quality time. More than using the screens to communicate, voice integrated personal assistance is a new experience that makes their life easy. Based on the results, researches presented appropriateness of the voice integrated personal assistance to the elderly long term patient care domain.

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Acronyms

API	Application Program Interface
HCI	Human-Computer Interaction
IDE	Integrated Development Environment
NLP	Natural Language Processing
NLU	Natural Language Understanding
SDK	Software Development Kit
VIPAs	Voice Interacted Personal Assistants

Chapter 1

Introduction

Long term patient is an individual who suffers from a chronic condition which needs long term care [1]. Long-term care consists of various services that facilitate the medical and non-medical needs of an individual during a short or long period of time. When people could not perform their daily tasks independently and safely on their own, they can use the services provided by long term care. Long term care can be provided by different caregivers according to the needs of patients. Long term care is provided in various places such as a hospital, a nursing home or an adult day care center. But in most cases, it is given at home by family members or friends as a volunteer service. Usually, the term chronic is used when the disease goes on for more than three months. Arthritis, asthma, cancer, diabetes and some viral diseases are some of the typical chronic diseases [2]. Moreover, the people who disabled due to accidents, wars or the ones who cannot maintain a normal life also need long term patient care. Due to the loss of their hands or legs, they could not proceed with their daily operations normally. Therefore, they always expect the assistance of a caretaker.

When looking into the patient care domain there are different types of patients without any age limitations. Some patients need small-term care while other patients require long term care which exceeds three months of period. Due to different age categories and interests of the patients, their needs and interests would differ. As an example, a child patient has different requirements compared with an older patient. When considering the long term disabled people who got disabled due to different accidents and wars may have different needs. Age, living environment, and interests are major factors that define the psychological needs of people.

Older adults can be also considered as long term patients somehow. Even though long-term care is not limited to the elderly, the vast majority of long-term care recipients are older. If we consider ten people who are over the age of 65 years, seven people require some sort of long term care services in their lifetime. There is a 50% chance of requiring long term care for a person who reaches the age of 75 years [3]. Taking care of a patient or an elderly parent would be difficult in this era as many people are so busy with day to day schedules. Patients, as well as older adults who are in the same place for a long period of time, may raise issues such as isolation, loneliness, and boredom. They may be compounded by mobility issues. Since there is a vast area in the long term patient care when based on different areas of interests of the patients. Within the

research, we mainly focus on elderly patients with different disabilities. They have different social, communication, and psychological requirements compared with young patients. Even in the long term patient care domain, there are many different categories of people with different requirements. Based on their living environment, disability they have physical, psychological needs may vary. However, this research is conducted mainly focusing on long term patients with mobility issues.

In the long term patient care domain, we can identify many types of research to improve the quality of life and to assist the caretaker. Numerous advanced technologies are used by the researchers to assist long term patient care. From those technologies, Natural Language Processing plays a major role in the domain. Since people in different social statuses, abilities, inabilities can have customized solutions that add more value to them. Natural Language Processing (NLP) has been a very important advancement in conversational interfaces which is used in Voice Integrated Personal Assistants technology. Any user interface that emulates a conversation with real humans using its own human terms in a way that humans only need to tell what to do to get something done by it, can be considered as a conversational interface. Voice Integrated Personal Assistants (VIPAs) are a subset of Automated voice-based conversational interfaces. VIPAs can be really helpful in early mentioned situations in long term patient care if it is customized to their special requirements. It can act as an assistant at the same time giving independence to the patient.

Voice integrated conversational interfaces are more suitable to assist long term patients in many ways. Conversational nature of a VIPA can be used to mitigate loneliness and isolation. It is easier to speak and ask something than typing or dialing a phone especially for patients with vision impairments or mobility issues.There is a challenge for patients and seniors to interact with computers and to do texting like things. If they use voice it simplifies things. Voice can be more natural and intuitive in interactions. So it is good for seniors. Even though we think that everyone is computer literate, the best way to interact with seniors and such patients is voice. VIPAs provide immediate responses as well as they can ask the same thing several times if they have issues with comprehension. Planning and successfully executing this kind of technology in the patient care domain is the challenge.

1.1 Problem Statement

Determine issues of long term patients which can be addressed through a conversational interface and develop a software application integrating conversational interface in a way that delivers more value to long term patients.

1.1.1 Major Research Problems:

Research focuses on smart conversational interfaces and necessities of target long term patients which can be accomplished by using conversational interfaces. Therefore the study mainly focuses

on figuring out the answers to 3 main research questions mentioned below.

1. What are the most common issues facing the elderly in assisted living?
2. Which of these issues can be addressed using an automated conversational interface?
3. What are the most effective ways of improving the quality of life through a conversational interface?

1. **What are the most common issues facing the elderly in assisted living?**

   There are different types of needs and wants for patients with long term illnesses. They may face many issues when they adapt to their lifestyle and doing their routine activities. To complete those tasks they always need to have a helping hand. Most of the patients have a separate caretaker to help in their tasks. Yet most of the patients would like to spend a more independent life when it comes to long term illnesses and adapting themselves. Identifying the issues that they face when spending an independent life would support them to adapt more easily. Therefore, in the preliminary stage of the research researchers are mainly addressing this problem. Selecting a suitable method for data gathering and conducting requirements gathering would address the above research problem. In the first phase of the research design and methodology; awareness of the problem and literature research, researchers focused on answering this research question.

2. **Which of these issues can be addressed using an automated conversational interface?**

   After the requirement gathering process doing in the first phase of research design and methodology; Awareness of the problem and literature research, researchers have to filter and identify the issues that can be addressed using conversational interfaces. All issues faced by the long term patients cannot be addressed by the conversational interface.So researchers have to study the capabilities of automated conversational interfaces', which of these capabilities can be used to address the issues identified in elderly and long term patient care domain and how the capabilities and issues can be mapped. Researchers need to prioritize the issues that can be addressed using a conversational interface. To answer the research question researchers need to get a deep understanding on how the conversational interfaces are currently used in the patient care domain, what are the most critical sections, what features needed to improve and what features needed to be customized for the domain we are considering.

3. **What are the most effective ways of improving the quality of life through a conversational interface?**

   Conversational Interfaces would improve the quality of life in different perspectives. From all the explored ways what would be the most effective ways to add value to the long term

patient care. The conversational interfaces such as google home mini, amazon echo have their own specific features. Besides, most of the features are common in general. From the features identified we can develop the model to cater to the issues and add value to the long term patient domain. Identifying the most effective ways to develop the model is a crucial part of the research. The conversational interface technology can be used to improve the lives of patients to complete their tasks with less effort and helping them to be more independent. Moreover, after identifying the more effective ways to improve the quality of life, how it adds value to these long term patients. It is useful and really convenient for them to use conversational Interfaces to do those tasks. We address the necessities using the conversational interface and make their life better. Other than these, the proposing architecture by the research and the development of the interaction model has to be designed and developed to cater to the other identified issues.

1.2 Project Motivation

When looking into the patient care domain there are different types of patients it can be a child patient or an older patient. When considering elderly long term patients, one of the main socio-economic problems in developing countries is increasing the number of elder people. In 2001, over 9% of the population in Sri Lanka was 60 years of age and over, which is a relatively large elderly population for a developing country. With the increasing number of elderly people, the whole society gets the responsibility of taking care of the elders. To take care of the elderly long term patients many caretakers have to be employed. Even though there is a caretaker, still looking after long term patients is a challenge. To assist the issues in the long term patient care we can use the technology.

As well as the elderly population, the long term patients with disability issues such as mobility, vision and other issues which need a caretaker to help them to complete the daily tasks that they are carrying out. Therefore we can use technical devices to help them to be more independent and carry out their tasks.

Hence using the conversational interface technology we can assist the long term patients to improve their independence and quality of life. Communication is the main necessity of humankind. People use different communication mediums to communicate with the people who are closer to them and to the people who live all over the world. Therefore, the research is mainly conducted to address the communicational requirements of the long term patients through conversational interfaces hence improve their independence.

1.3 Research Approach

The research conducted adopting a mixed approach where both qualitative and quantitative analysis was carried out. A qualitative approach used to analyze the data gathered through inter-

views conducted with elderly patients, caretakers, relatives of those patients and among others to understand the behavior of daily activities and the difficulties they find in engaging in them.

Analyzing Amazon reviews data collection which is described in the research methodology section, gone through both qualitative approaches as well as quantitative approach. Evaluation of the introduced solution carried out with the engagement of long term patients. The participatory design approach was adopted in the design artifact designing phase, in that stakeholders like patients, caretakers, their relatives, researchers, and end-users were all involved in the design process of the research in order to ensure that the end product meets the requirements of its intended users. Figure 1.1 depicts the Work Breakdown of the Research.

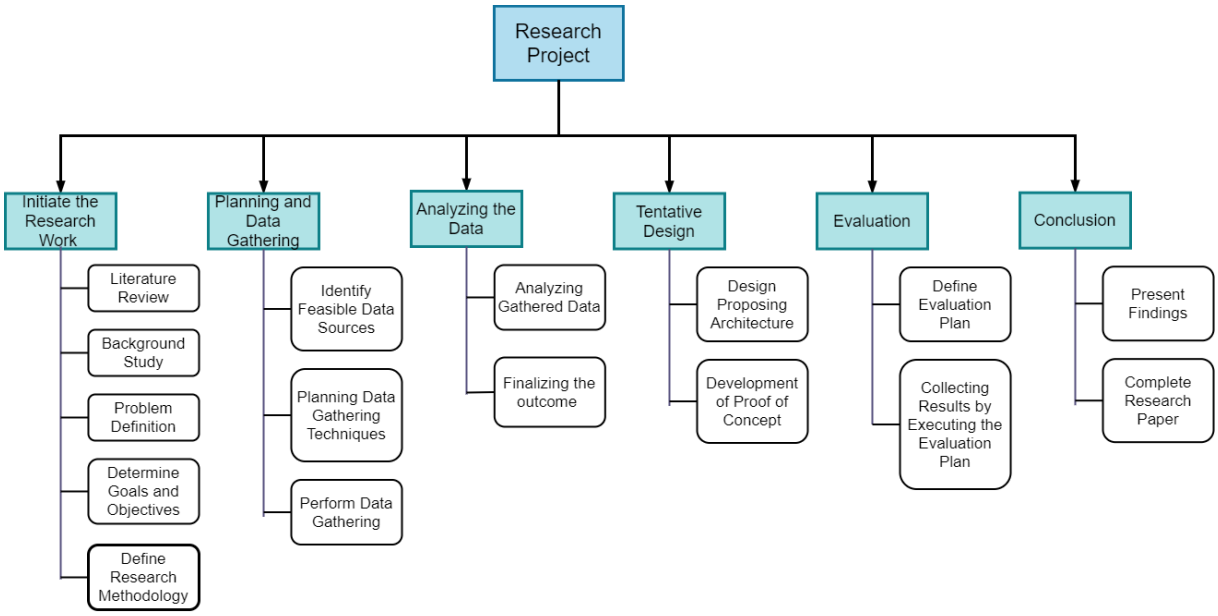

Figure 1.1: Work Breakdown of the Research

1.4 Research Goals and Objectives

1. **Carry out a survey of key stakeholders of assisted living: inmates, caregivers, family members to identify the most critical issues faced by the elderly.**

   According to the introduction of the research, one of the major objectives to achieve is to identify the difficulties of patients with long term illnesses. Long term illnesses adversely affect certain patient day-to-day functioning and overall quality of life. So they may have difficulties when compared to normal people when they need to fulfill their daily requirements. Therefore this research was focused on carrying out a survey of key stakeholders of assisted living: inmates, caregivers, family members to identify the most critical issues faced by the long term patients and also research was focused on extracting related issues and benefits of conversational interfaces using the Amazon Echo reviews by above-mentioned stakeholders.

2. **Analyze, design and develop a conversational interface to best assist elderly patients in long term care.**

   After the gathering of the required dataset from long term patients, the prioritized psychological issues and mainly communication-based needs that can be addressed by a conversational interface identified. A conversational model was developed for those prioritized issues while considering participatory design methods. From this development, users will get the chance to satisfy most of their issues from a single system without any hassle.

3. **Evaluate the effects of the interaction between the elderly and the conversational interface.**

   After finalizing the prioritized issues to be addressed by the conversational interface based system, a sample will be chosen to test the way they engage with a conversational agent to satisfy those issues. Implementing a solution for these elder patients alone will not visualize the success of the research. So there will be an evaluation process which acquires both qualitative and quantitative measures from a selected sample of long term elderly patients. Evaluation will be prepared considering different perspectives which are related to the interactive model that is being developed.

1.5 Scope and Delimitation

1.5.1 Scope

The scope of the research was based only on targeting a group of patients who suffer from long-running illness and who could not handle their day-to-day life without immediate care of a person. And for the demonstration of the system development, we considered the voice assistants as conversational interface bases for this research such as Amazon Echo, Google Home.

Data gathering was done using Amazon echo reviews related to long term patients. The interview study was carried out for requirement clarification purposes and for understanding the current day-to-day life of long term patients. The sample for the interview was a group of patients aged between 60 and 95 who suffer from long-running illnesses in Sri Lanka. The living environment of the selected sample of elders is the home environment.

In interviews, Data gathering was conducted in the local language and findings were translated into English due to language barriers in technology. The research did not focus on any specific patient category with a specific disease but only considered patients who suffer from long term diseases and considered common issues which can be addressed by using a conversational interface.

Target set for the evaluation was also a sample of elders who live in a home environment who suffer from long term diseases. The implemented interaction model was given to them for use and

evaluated measures using both qualitative and quantitative data collective manners.

1.5.2 Delimitation

- We gathered data in both Sinhala and English. When it comes to testing the sample patients must be fluent in English to communicate with the device. Therefore, we had the language barrier as a limitation.
- Due to the time constraints, we selected only one iteration in the design science research methodology. By increasing the number of iteration we can improve the effectiveness of the research.
- The review analysis is basically conducted on the Amazon Echo device. Therefore the results taken from the reviews are limited to the features of Amazon Echo.
- Reviews can be biased and misleading due to various kinds of perceptions being included in the reviews.
- The evaluation carried out using a questionnaire considering their satisfaction during the usage of the developed interactive model. Hence, any change other than the system change which causes the feedback process was not considered such as medical situation changes.
- People may provide bias or false opinions in interviews and evaluations which can be misleading. It is difficult to get the opinion on the device after using the device only for a short period of time.
- The model is developed based on the google home mini device. Therefore the suggested solution is limited by the google home mini features. Some of the features are not available based on the location in google home.

1.6 Significance of the Study

The study will provide relevant information regarding how conversational interfaces can be used in long term patient care space effectively. As mentioned previously, there are only a limited number of research conducted in this domain and also found that there is a gap in catering these conversational interfaces to long term patient care space.

Overall opinion, benefits, and problems of the users are analyzed systematically to show how the patient care domain is facilitated by the voice integrated personal assistance. The study shows the ways of using the voice integrated personal assistance by different patients and elderly people.

A comprehensive interview study (qualitative study) on the long term patient care domain in Sri Lanka is carried out to identify the varying necessities of the long term patients, and the elders. The study mainly focused on the lifestyle of the elderly residing with their families.

As the final outcome of the research, the proof of concept is presented to address issues identified in the patient care domain. A model was designed using the participatory design to cater to the identified requirements.

1.7 Overview of the Dissertation

In chapter 1; the Introduction focuses on explaining the problem identified while explaining the domain it is implemented to. The problem statement and major research questions are addressed in the introduction chapter. Also, the chapter provides a deep description of the project motivation, approach, objectives, goals, scope, and delimitations of the research study and a brief description of the significance of the study. Chapter 2 which is Background and literature review, serves as the foundation on the domain in which the study is built and several areas of interest related to the problem. Also, this chapter review previously carried out research on this domain and what has already been written in the field on the topic of the research. It includes the systematic literature review which was carried out based on research questions.

In chapter 3, Design and Methodology, describes the research methodology in which the research could be replicated and the processing of them in detail. Especially the chapter includes the design and implementation of the suggested model for addressing the research problem. Chapter 4, which is the Implementation chapter, includes the implementation process carried out throughout the research in order to emphasize the idea to the community of long term patients and in chapter 5, Analysis and Results, analysis of the evaluation process of the study is included. In this chapter, the reporting of the study results and the detailed analysis process are presented. Thereafter in chapter 6, Discussion includes the interpretation of the results and discussed them in conjunction with the relevance to the study context. Limitations of interpretation are also included here. Conclusion, summarized the importance of the study findings and concluded the research study. Future Work, provides specific guidance based on future research options along the pathway of continuing this research.

1.8 Summary of Introduction Chapter

The introduction chapter, in the beginning, provides an introduction to the problem identified for the study. Then it clarifies the motivation of the study so as to why this study ought to be done. Then it likewise clarifies the objectives of the study. As the next component, the scope has explained. It describes the boundaries of the study. Delimitations of the research study explained justifying what the study has controlled to achieve the targeted time frame and the complexity as the next phase of the introduction. An explanation of the value of the study has included here as the significance of the study.

Chapter 2

Background and Literature Review

2.1 Chapter Overview

In the background chapter, the domain of the study area is described in detail. The chapter includes a literature review and background information. This focuses on many related study areas in the domain and identifies the previous research done in those study areas. It includes the background information and terminology that have been reviewed to spread the knowledge in the problem domain. This focuses on many areas that are related to the study and identifies the previous research that was carried out with references. The chapter includes domain systemic review on patient care in global as well as patient care in Sri Lanka, Long term patient care and the barriers. The importance of productive interaction, voice interacted personal assistants, voice interaction technology in patient care and voice interaction technology with elderly users are discussed in detail. After reviewing the previous researchers, the research is conducted mainly focusing on the long term patients with mobility issues. When analyzing the background we identified many technologies combined with conversational interfaces used to provide a better service in the patient care domain. Smart technologies, Architecture and wearable technologies provide a significant background to this research domain. The details of background research done on the previous research are discussed in detail.

2.2 Background

2.2.1 Patient care

When developing in the patient care domain, it should always be patient-centered. Furthermore, it should involve the patient. Patientcare is services accomplished by members of the health care professionals and non-professionals such as caretakers or caregivers under their supervision for the benefit of the patient. [2] In the patient care process it is very important to identify the requirements of the patient prior to addressing them. In the process, we have to identify their capabilities to interact with technology. Then only they can gain a required output as they expected. Technologies in the current elderly patient care cater to different groups of people in a customized

manner. There are many models, architectures developed for the patient care sector. Advanced technological accessories and sensors are used to provide more caring for patients. Building smart home environments, health care application and voice interface applications are few of the areas covered in the patient care domain. When we consider smart home applications in elderly patient care, there are many applications. In a smart home environment, IOT based Indoor location detection system, fall detection, and communication architecture. In these frameworks, conversational interfaces play a major role when interacting with elderly patients.

2.2.2 Long term patient care in Sri Lanka

In Sri Lanka, most of the time long term patient care is happening mainly in a house. Long term patients such as people with mobility issues, older adults, people with extreme diabetes issues are mainly cared for by their family members and their caretakers. Most of the time they are not with professional health caretakers' supervision. Previous studies in Sri Lanka have found that the lack of knowledge of diabetes, poor attendance at clinics as the main issue to occur complications of diabetes[21]. So there are needs for proper supervision as well as proper interaction with caretakers and patients in Sri Lanka.

2.2.3 Conversational Interfaces in health care

Development in voice recognition technology, artificial intelligence and NLP have led to more applications of conversational interfaces in many areas. Popular examples of conversational interfaces are Google Home, Amazon Alexa, Apple Siri or Microsoft Cortana. Using voice enabled conversational interfaces which can input natural language for health related purposes is a rising field of research. Even though in other application domain use of conversational interfaces is increasing, the use of conversational interfaces in health care is relatively low [27]. Same time, we can see developed countries most of the time use these conversational interface technologies in healthcare as well as other domains but developing countries like Sri Lanka still have not been to that level.

2.3 Related Work and Literature Review

We conducted a systematic review based on the five stages of Conducting a review [16] on the use of conversational interfaces in long term patient care. The purpose of the systematic review was to examine previously published studies that provide the knowledge on the research carried out before on this area, the clashing perspectives that have emerged and the gaps that are available among the previously carried out research.

2.3.1 Literature Review

Conversational interfaces and people interaction

Nowadays people use conversational interfaces for their day to day life activities than previous years such as to obtain assistance or information, for entertainment purposes, to improve social interactions with other people, also out of curiosity [22]. More than just a companion people use it as an guidance seeking purposes, health-related purposes and also for other important day to day activities.

Barriers in long term patient care

Since long term patients suffer from long term diseases and health problems they tend to occur difficulties and barriers in their day to day quality of life. Some research studies found that long term patients suffer from difficulties such as lack of participation in physical activities due to fear of falling, insufficient understanding about physical activity [17] as well as in terms of physical health benefits[18].

Conversational interfaces and patient care

The conversational interfaces help in delivering advice about medical conditions, proper health education and behavior change investigating purposes [4]. Researchers investigated personalized versions of those conversational in various patient groups such as in Diabetes [5, 6], disabilities [7], and also considering with patients therapists or physicians groups [8]. A study conducted by S. Hussain, et al. [6] stated that virtual agents can help patients to educate them about their condition so they can better manage it. Work done by T. Bickmore by et al. [4] demonstrated intervention that combined a smartphone-based virtual assistant and a mobile heart rhythm monitor to help patients with chronic conditions and found that participants had different habits when using the system such as interaction is conducted mostly either in the morning or in the evening, some participants used the coach when they were taking their medications. and the patients got notable developments in their quality of life. To enhance the value of the life of patients there should supportive regular communication regarding advantages, such as educating patients about the ways providers use patients' preferences to personalize the care maintaining process[9]. People with disabilities use VIPAs as an accessible technology in their day to day life activities as well as special situations such as speech therapy and support for caregivers [7] and the use of VIPAs overcomes their physical limitations by enabling a sense of control and independence of the life [10].

The work carried out by et al concluded that most people represent the Echo as an assistant, a friend, or a family member [10]. Regardless of the type of disease patients use VIPAs as a source of assistive technology[5,6]. Cheng, A., et al. [6] deployed a healthy coping application by utilizing Google Home and API AI platform to improve the monitoring of diabetic consequences of a certain patient which promotes self-management of type 2 diabetes among elderly patients.

Also, the work of Ballati, et al. [5] showed that Google Assistant performs better when used by people with dysarthria.

Conversational interfaces and elderly patients

Voice has the advantage of being a natural and intuitive form of interaction for most people. That makes it a good fit for seniors: A technology iteration that feels familiar right from the start. Although we thought that everyone is computer literate, the best way for seniors to interact is by voice. Some papers have discussed the Social interaction of elderly people through VIPAs [11,12]. There are numerous instances of social isolation, rejection, and loneliness when considering elderly people. Social Interaction and social bonds by the person with the families, friends or co-workers can be identified as more important factors of the quality of life of elderlies [12]. Considering elderly people, Social isolation has a significant impact on general health and appears by weakening social interaction. Social isolation is commonly correlated with the weakening mental health of a person, which can cause mental disorders like depression. Supporting elderly individual social engagement can directly preserve good mental health. With the evolution of information technology, several applications can be found to provide communication medium [11]. These technological devices give great help for seniors to stay independent as they can get help from these devices to accomplish their tasks on their daily routine. Verbal reminders like a timer to take medicine is useful to help with memory issues. VIPAs are a great source of entertainment as they can play specific songs, read e-books, listen to the news or listen to jokes for seniors as user requests. The devices can even replace TV remotes and light switches with verbal commands, which can be ideal for senior people who have mobility issues. There are vision challenges that many seniors have that limit their ability to interact with the computer or to do things like texting or searching the web. When they can use their voice, it simplifies things. Other than VIPAs different types of conversational interfaces can be used to assist elderly people who may show physical limitations as well as restrictions in their vision and hearing like chatbots, avatars and virtual agents[13,14]. Most papers indicate that voice can be seen as an efficient and engaging input modality for seniors, in cases if they suffer from age-related physical restrictions [15].

2.3.2 Previous Research / Similar Work

A study carried out by Dojchinovski, et al. (2019) [23] discussed the application of Interactive home healthcare system with integrated voice assistant to demonstrate patient-focused voice and web services developed for Amazon Alexa and Google Assistant and pinpoint the benefits of this technology in healthcare in the comfort of the patients home. And researchers focused on solving the obstacles patients face when using wearable health sensors in their home environment. Such as lack of convenient tracking of readings, as well as misunderstanding of sensor readings, by handling the responsibility to the Amazon and Google voice assistants. And they stated that voice assistants can make suggestions and even schedule a doctor appointment, make reminders of the actions needed in the prescribed therapy and before appointments.

X. Fan et al.,[24] conducted a study using activity Recognition as a service for smart home ambient assisted living applications via sensing home. Through the study, they propose a feasible extended framework that is compatible with common devices and protocols where home automation, environment and health management and advance warning of risk can be directly applied using this service. In the study they mainly focus on identifying the physical activities of patients but there is a knowledge gap how to cater smart home solutions to improve their communicational and psychological needs. Moreover researchers Rosruen N. et al.,[25] utilized chatbot as a medical consultant system. In this work, the development of medical chatbot using Dialogflow was done. And researchers found that the system increases convenience to the users, service capability and decreases the cost of medical consultant services.

Research carried out by Han S. et al. [26] developed a rehabilitation training coach robot for patients with disabilities to help at-home patients do their rehabilitation exercises at home without any professional trainers. Here suggests the rehabilitation program and corrects the posture of the patients during the exercise. The deep neural network is used for posture correction. Besides, the voice interface based on neural network is applied for convenient interaction between robot and patients during the exercise. The voice interface of the proposed robot is only able to recognize and synthesize pre-defined commands. But in the research, researchers haven't used any NLP processes due to integrating them with the proposed system will increase the cost and need for more processing power. Also, these kinds of bots are costly for the global community with different social statues. Therefore there is a gap in the domain to integrate the NLP process in the community of patient care with considerable price limitations.

Therefore according to systemic literature review researchers identified there is a knowledge gap in the research community in the domain of investigating a way to improve psychological and communicational needs of long term patients through smart technologies

Chapter 3

Design and Methodology

3.1 Chapter Overview

The design and methodology chapter describes the research methodology in which the research could be replicated and the processing of them in detail. Chapter especially includes how the research methodology is used to conduct the research in different phases and comprehensive outlook of the research methodology..

3.2 Design and methodology

As research was focused on developing a voice agent for long term patients which is an information systems research, we conducted the research based on design science research methodology principles. [19]

1. Awareness of the problem and literature research
2. A suggestion of an initial design and development of design artifact
3. Demonstration and evaluation of the solution
4. Communication with related community

According to the methodology research design was created. Figure 3.1 depicts the design science research step which researchers have adopted in their process.

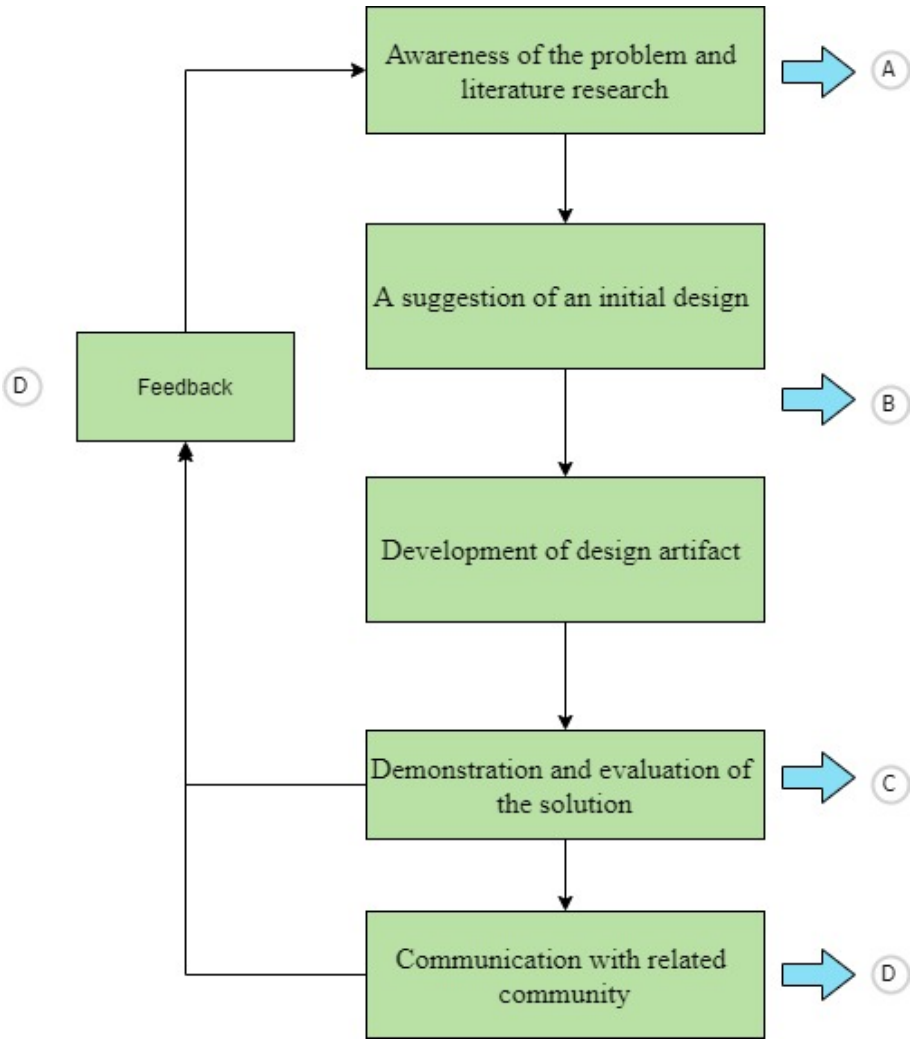

Figure 3.1: Adopted design science research methodology steps

3.2.1 Awareness of the problem and literature research

Amazon Echo is a third-generation chatbot conversational interface that can connect to the voice-controlled intelligent personal assistant service Alexa. Therefore conducted an exploratory study based on publicly available online customer reviews of Amazon reviews that mentioned use by an individual with long term illness in order to investigate what context conversational interfaces have been used in patient care. For the Amazon review analysis process, we collected a total of 621 reviews for the analysis by using defined search terms. The removal of irrelevant reviews resulted in 455 Amazon Echo reviews from Amazon.com in June and July 2019 as for the sample and reviews which are qualitative data, were also analyzed using thematic analysis methods using six phases[20].

Phase 1: familiarizing with gathered Amazon review data collection

We searched for Amazon Echo reviews through Amazon.com using search terms we defined after getting proper domain knowledge. The inclusion criteria for reviews were segregated based on three categories.

1. Different types of long term patients' and related people definitions related keywords such as "Elder", "Older people", "Senior citizen", "Grandparent", "Grandfather", "Grandmother", "Patient", "Elderly", "Caregiver".

2. Disabilities and diseases related to long term patients such as "Mobility issues", "Limited mobility", "Chronic", " Sick", "Ill", "Motor disability", "Disability", "Disable", "Alone", "Disease", "Health issues", "Suffer from", "Less walk", "Physical disability", "Lonely"

3. Living environments related to long term patients such as "Assisted living", "Hospital", "Care home"

We gathered related reviews based on prior domain knowledge using the above-mentioned keywords separately and also using combined keywords using boolean "AND" operator. Collected data were read repeatedly to search for meanings and patterns of those reviews. While reading possible patterns of users were marked and taken notes of important contents.

Phase 2: generating initial codes for the data set

Researchers used the Nvivo software tool for the coding process of the dataset and also added meaningful codes manually to get deeper identification of features in data based on our domain knowledge which appears interesting regarding the phenomenon. The dataset was coded into 333 codes. Table 3.1 shows initial codes created for the research data set. Code book was created.

Table 3.1: Sample of Initial Codes created for the research dataset

Initial codes
Addition - great addition, smart home addition — App - actual app, android app, music app, weather apps, communications devices — Bedroom - bedroom door, bedroom light, floor master bedroom, bedroom light, bedroom light — Calls - 911 call center, call companion, call notifications, calling icon, incoming calls, ordinary phone calls, outbound calls — Care - geriatric care providers, local caregiver, companion,Independence, rehab center, chronic case — Conversation - full conversation,household conversations — Days - days events, tiring day — Device - communications devices, device settings, echo device, handy device, managing devices, smart home devices, worthy device — Family - family hands, family members — Functions - functionality questions, memory functions, music functions — Gifts - great gift, technology gifts — Age - younger adult, older adult, unspecified — Disability - Motor, vision, Hearing, Memory loss — Listening to jokes, news, Playing radio, Reading e-books, Set reminders, Alarm — Home - average home, nursing home, parent home, senior citizens, homes, senior home, smart home addition, smart home devices, smart home lighting — incoming calls — Issues - left performance issues, medical issues, suffers from balance issues — leg - left leg, non-surgical leg, surgical leg — Library - local library , music library — Light - bedroom light, hallway light, living room light, smart home lighting — List - play list, shopping list — Member - additional member, family member — Memory - memory functions, short term memory — Music - ambient music, familiar music, music app, music functions, music library, overrated music box — happy owners — Performance - horrible performance, left performance issues, speaker performance — Phone - ordinary phone calls, phone landline, phone numbers, phone rep, phone, representative, smart phone, phone landline, phone numbers — Price - checking prices, great mid range price, wonderful product, good quality, sound quality — Review - bad review, positive reviews — senior citizen - senior citizen community, senior citizens homes — smart home - smart home addition, smart home devices, smart home lighting, smart home lighting, smart home lighting — sound - good sound, smooth sound, sound intensity, sound quality —super fun - super fun — Time - different times, great time, huge time saver, story time, time information, weather updates — Voice - gentle voice, voice recognition — Weather - especially weather, weather apps, weather forecast, weather reports, weather updates

Phase 3: searching for themes in collected data

Above mentioned codes were gathered and analyzed for themes manually. We sorted various codes into potential themes in order to get a proper idea about relationships between codes, between themes as well as themes. Codes were categorized into themes, sub-themes and also

non-related codes were discarded. Codes encountered with meaningful five themes. Table 3.2 illustrates the resulting themes from the Amazon analysis.

Table 3.2: Resulting Themes and Sub themes From the Amazon Analysis

Themes	Sub themes
User characteristics	Age, Living environment, Disability, Disease, Caretaker availability
Device usage	Information seeking, Set reminders and Alarms, Calls, Managing a list, Third-party app usage, Home automation, Entertainment usage
Reliability	Taking as a companion/caretaker, Helpfulness to caretaker, Independence level
Limitations	Privacy concerns, Security concerns
Device engagement	Device Interaction, Rating, Speech recognition

Phase 4: reviewing themes in the area

In this phase we investigated whether our candidate themes pattern and if it doesn't have, we created a new theme or discarding them. Figure 3.2 depicts the outcome of this phase which is the thematic map for the analysis.

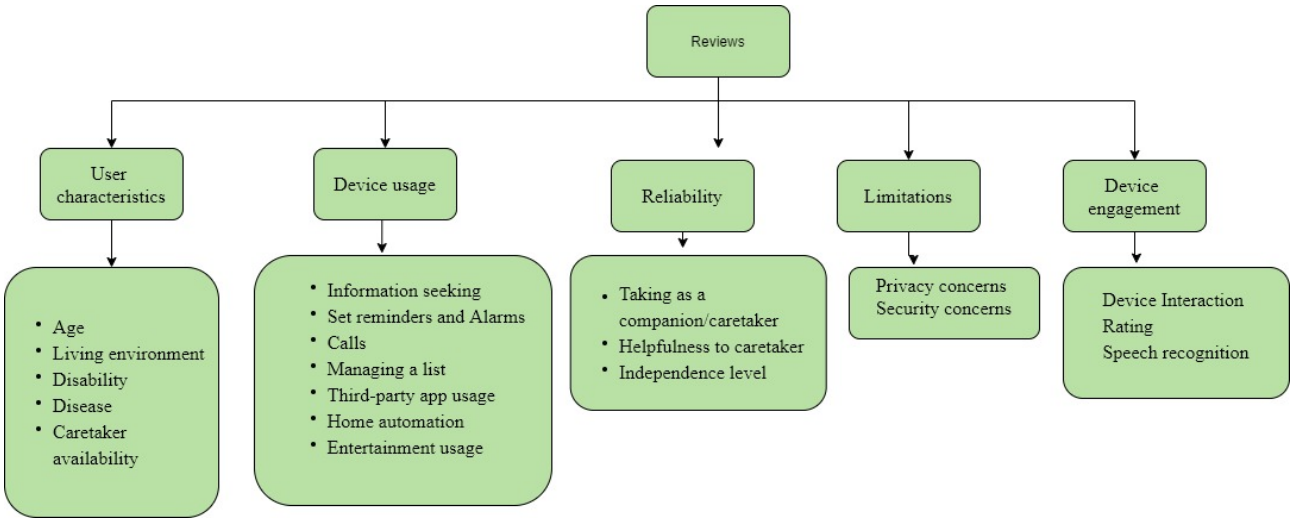

Figure 3.2: Sample Thematic Map

Phase 5: defining and naming themes

In this phase, we investigated the meaning of each theme and determined the data each specific theme captures and additionally we identified sub-themes for those main themes.

Phase 6: producing the report

In this phase, we created a detailed report of our created themes from analyzed data. There are 5 themes and 20 sub themes in those different themes.

Theme 1: User characteristics

Age

When collecting reviews for the analysis we searched for reviews that mentioned a user who is an older adult or a user who has a long-running illness or a disability. From the selected set of reviews 72.3% were mentioned about a user who is an older adult. 8.6% reviews mentioned a user who is a young adult while 19.1% reviews did not mention any age-related keyword.

From the data about older adults, 82.4% reviews have rated the device with 5 stars showing older adults are really getting an advantage of the device. For example;

"all I need is to talk to it it's very cool especially when when you are old and can't move or when your sick."
"THIS LITTLE ITEM IS A TRUE GEM FOR SENIORS!!"
"it's a necessity for older folks like my mother (for whom the Echo is a great life-enhancer)"

However some reviews have stated that the device is not suitable for seniors as well. For example;
"She refuses to ask it what day it is. She'd Rather find out on the television menu, or look at the wall calendar we have. She even unplugged it once! I swear someone needs to make an Alexa Silver for seniors"
"I bought the Echo for my 83 year old Mother. What a mistake. . . .They have no clue what seniors can or can not do, how they manage with limited hearing and eyesight. It could be really wonderful for hundreds of thousands of elderly adults.... but now it's just a toy for children."

Living environment

In terms of the living environment, we categorized reviews into five categories like Home, Nursing home, Elderly home, Hospital and Other. The majority of the reviews mentioned the use of the device at home. 96% of the reviews demonstrate the user lives in a home. Remaining 18 mentioned use in an elderly home, nursing home, hospital, or another place.

Disability and disease

62.6% of users have mentioned a disability of the user. Out of them, 13.8% were vision disabled, 13.6% were motor disabled, 3.3% had memory losses and 4.4% had other disabilities. 25.3% were disabled but had not mentioned a specific type of disability. Figure 3.3 depicts the distribution of disability in the data set.

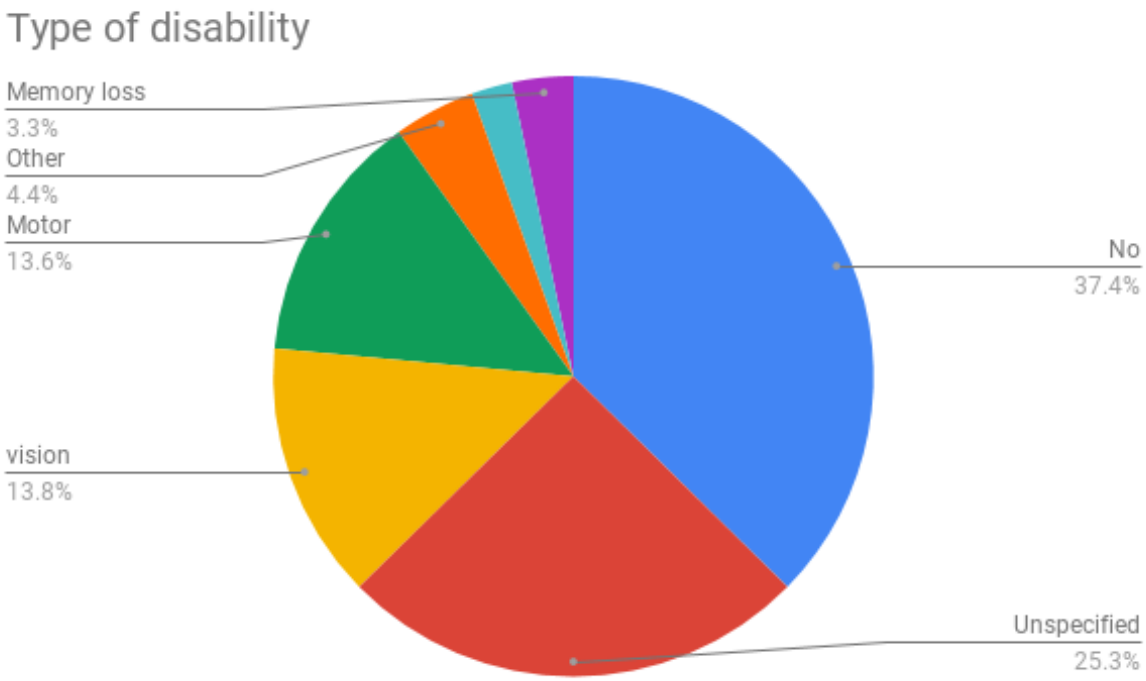

Figure 3.3: Distribution of Disability

In the dataset people with different types of diseases have mentioned. 141 reviews have mentioned a disease or diseases. Most of them are visually impaired/ blind and those who have Mobility issues. The gathered sample was not focusing ne any specific disease. A brief summary of them as follows, figure 3.4 depicts the summary.

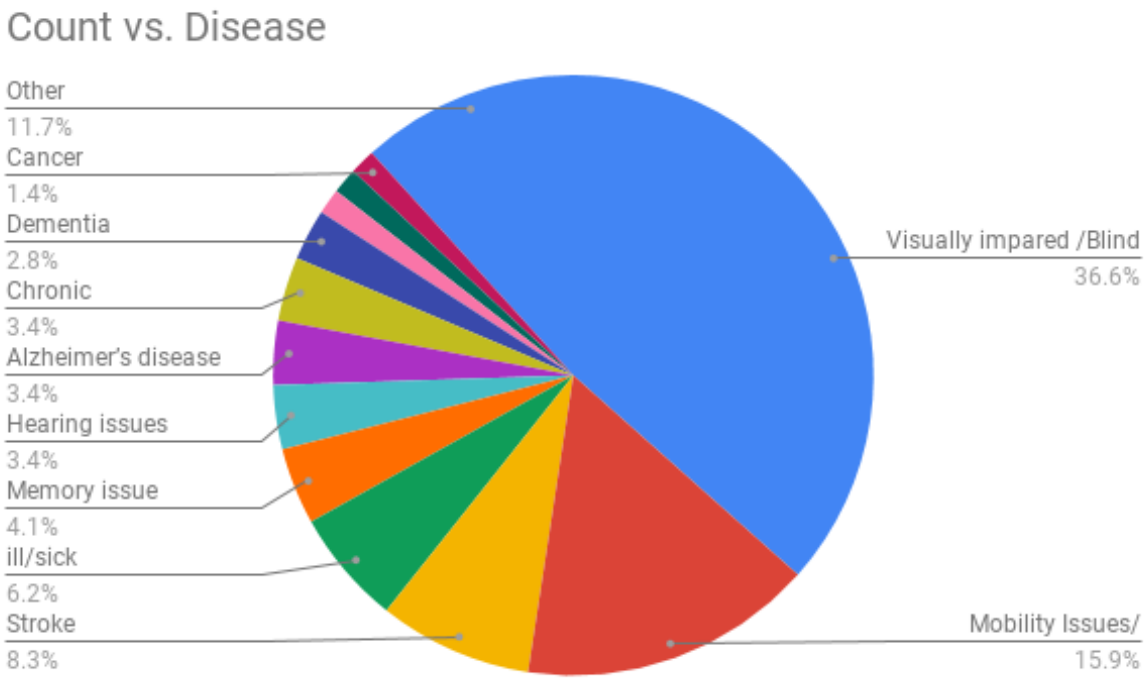

Figure 3.4: Distribution of Disease

Caretaker availability

20.2% review data shows that the user lives alone without any caretaker. The device was really helpful for those who live alone in their elderly age. For example;
"I'm alone a lot so it helps me get through my days since I'm disabled.."
"I highly recommend this for seniors who live alone and aren't great with electronics"
"I bought this for my elderly mother who lives alone and is not too tech savvy. . . ..Good for senior living alone"
"What a wonderful feature for someone who lives alone."

Reviews have shown the device is great in emergency situations for people living alone.
"I gave it as a gift for a disabled relative in case he falls while home alone. Peace of mind that he call someone for help."
"As a senior citizen I was concerned about living alone and having an accident. . . . . .. Now I know I will be safe and can reach help when necessary."
"I am encouraging all people living alone to get one if for nothing more than being able to call someone in an emergency." Theme 2: Device usage Majority of the reviews have mentioned one or more specific uses of the device which users used. Table 3.3 represents the findings of user device usage from the analysis of the Amazon reviews.

Table 3.3: Long Term Patient's Basic Uses of Conversational Interfaces

Need	Count	Percentage
Listening to music	232	49%
Listening to news	62	13%
Playing radio	64	14%
Reading e-books	37	7%
Information seeking	127	27%
Check the weather	76	16%
Set reminders/timers	77	16%
Alarms	31	6%
Calls	111	24%
Ask time/date	35	8%
Playing games	7	2%
Managing list	26	6%
Third-party apps	6	1%
Home automation	80	17%

Other usages found other than these are voice mail, using amazon skills, temperature, spellings, calculations, practice English, ordering items, and others. Figure 3.5 depicts the Usage with Age in the data set.

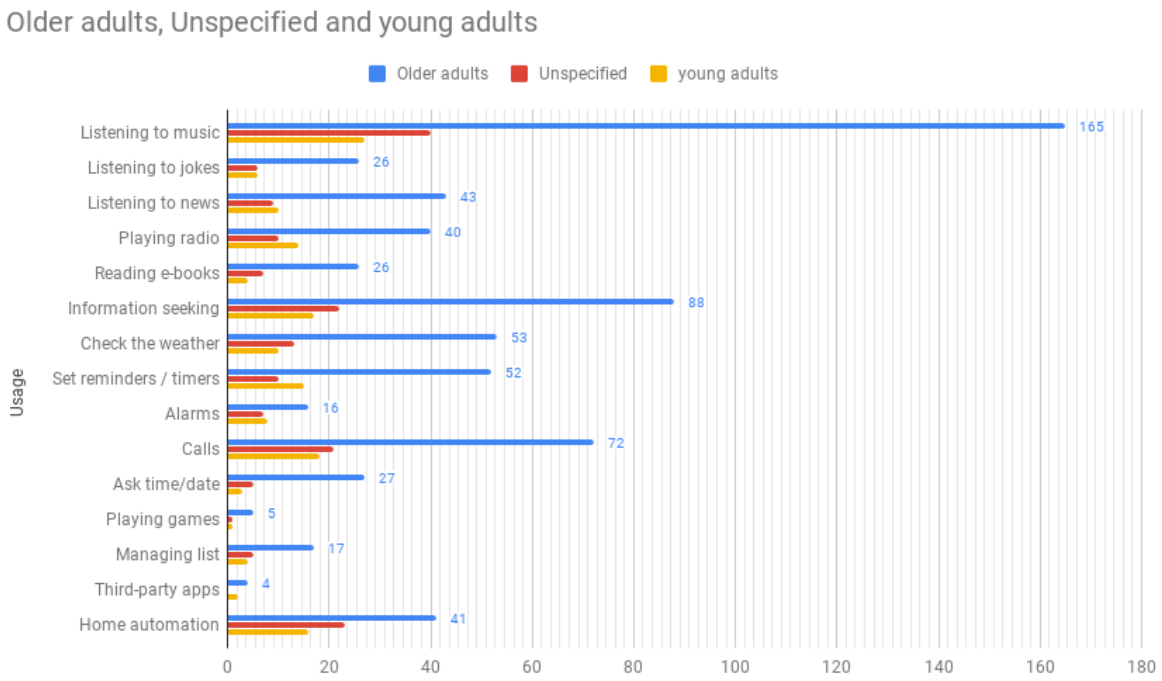

Figure 3.5: Usage with Age

Theme 3: Reliability

Taking as a companion/caretaker

From the reviews related to long term patients 26.7% have referred to the device as a companion/caretaker or a friend. From those, 70.9% reviews are related to older adults. These findings show that older people assume the device as their companion. For example;

"I am disabled and live alone. Now I have someone to talk to and I love it."

"I am a live-alone senior citizen and finally decided to give Alexa a try. We have become great friends"

"I no longer feel I am entirely alone with no one to talk to or to listen to.. She is the best purchase I have ever made....."

Helpfulness to caretaker

Out of 16% users stated the user has a caretaker and 82.4% state that the device has been helpful for caregivers in care giving. For example;

"My husband is disabled and bed ridden. While I'm at work I'm able to set a schedule for music to start playing, for the news topics to be read and for audible to start a book this way he can get interaction even when I can't be there."

"I have it set to remind my elderly ill mother to take her pills 4 times a day."

"I set up reminders for my elderly mother to remind her when to take her medicine...I'm taking care of my mother and my grandchildren in the same house so being able to do a quick check in while in a different room is great!"

Independence level

37.5% reviews in the review analysis states that the device has been helpful to gain the user's independence.

"I purchased this for my Brother-in-law who has ALS (Lou Gehrig's Disease).... A lot of independence has been taken away from him by this disease .....this gave him some independence back."

"I am writing a 5 star review for our Amazon Echo because it has actually changed my mom's quality of life.....my mom has gained independence once again ...You have given my disabled mother a little more independence and freedom."

"My husband has a vision disability and this device affords him some independence!"

"My grandmother is 100% blind and Alexa has given her back some level of independence."

Theme 4: Limitations

16% reviews mentioned limitations or suggestions such as No repeat reminders, No security safeguards for voice ordering, No compound commands, When changing the network everything gets erased, Long questions cannot be understood by voice assistants and Slower speaking option.

"Improvements surely are forthcoming but there are no security safeguards for voice ordering, so it seems best to leave that feature turned off for the device seems eager to order things without giving price information and just with a query."

Theme 5: Device engagement

Device Interaction

We categorized each review into device interaction level based on positivity or negativity of the review. Out of all reviews, 72.2% stated usage as comfort, 22.3% as moderate and 5.5% as discomfort.

Rating

Rating given for the device in the reviews showed on a 5-point scale. Over four out of five reviews (80.9%,368 reviews) have rated the device with 5 stars and 10.1% (46 reviews) have rated the device with 4 stars.21 reviews (4.6%) have rated the device with 3 stars. Only a small number of reviews have given a low rating to the device. This implies that most of the elders and other people with long term illness or disability who used a conversational interface like voice integrated personal assistant prefer to have it.

Speech recognition

We categorized each review into device speech recognition level based on positivity or negativity of the review. Out of all reviews, 63.1% stated usage as comfort, 33.2% as moderate and 3.8% as discomfort.

"I like these devices because they can help disable people have easier access to their home I.e. paralyzed people could control their ceiling fan or lights or music with their voice and are there-

fore more independent"

"Voice recognition is awful, have to stand right next to it and dictate like I'm screaming to a half deaf child in a tornado."

Figure 3.6 depicts the Spread of Speech Recognition in the data set.

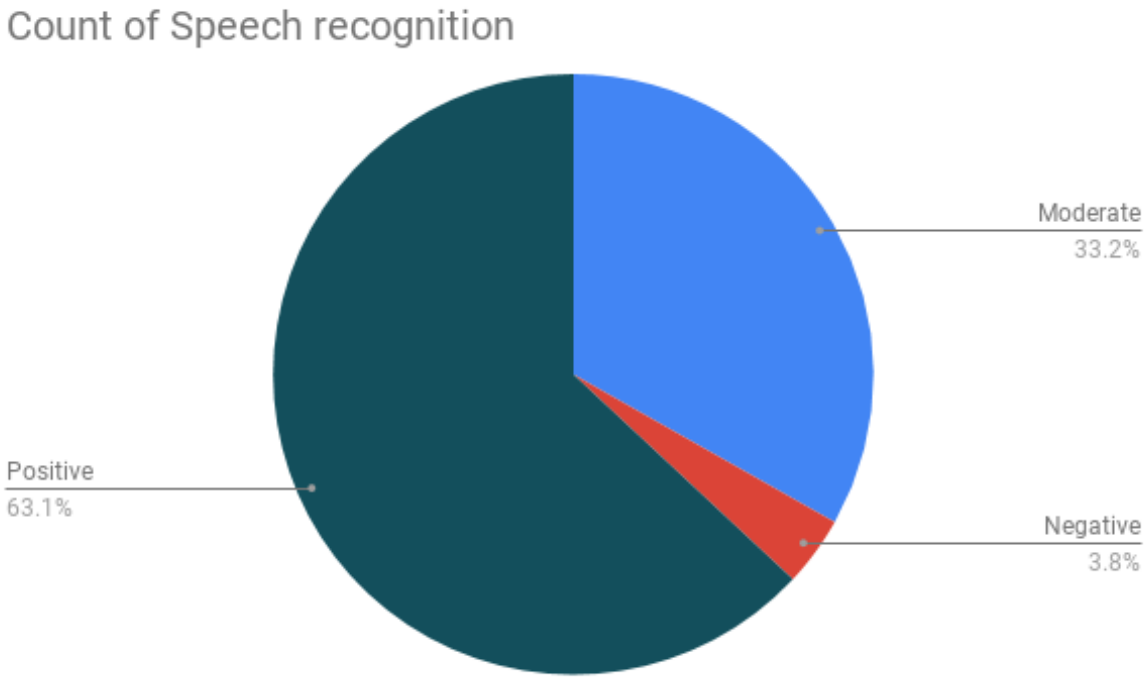

Figure 3.6: Spread of Speech Recognition

Also in order to get a deeper understanding of the domain area and identify common issues facing the elderly in assisted living which can be addressed by a conversational interface, we conducted an interview study among both long term patients as well as to their caretakers/caregivers. We interviewed 20 individual long term patients and 11 caretakers/caregivers of long term patients. The sample for the interview was a group of patients aged between 60 to 90 who suffer from long-running illnesses and who live in a home environment in Sri Lanka. We prepared 2 questionnaires (Appendix A) specifically targeting patients and caretakers. Interviews were conducted using both English and Sinhala languages using interview mediums such as face to face or using video calls and voice calls. For individual interviewees, the data gathered were analyzed using designing personas for them and findings were again analyzed using aforementioned thematic analysis method using six phases[20]. Familiarizing yourself with your data would be the first step. Secondly researchers must generate initial codes. Based on the codes generated, we search for themes and review themes Finally, researchers define and name themes to produce the reports in the thematic analysis. The gathered data were coded into Resulting needs of patients were themed into 4 clustered themes such as psychological, medical, social and communication needs. Table 3.4 represents the themes created for the data set.

Table 3.4: Themes Generated for interviews

Group	Long term patient need
Psychological needs	Getting rid of loneliness, Talking with someone, Entertainment needs - music, radio, watching television Live independently, Small reminders to save since they forget
Medical needs	Medication reminders, Exercise guidance, Proper diet management, Memory boosting activities
Social needs	Interacting with others through calls or social media Information seek - getting news, weather data Guidance to manage new equipment Sending messages to others
Communication needs	Alerting emergency situations, Making calls

Most participants stated that patients have loneliness issues when flowing day to day activities alone.

"She likes to do basic stuff like eating changing clothes etc independently but she likes to have someone by her side talking with her. She can talk continuously for like 1 hour. She likes to pet our cat like a person too. So actually she searches for lots of things to get rid of her loneliness in her way."

"He needs to be in supervision 24/7 due to lack of sleep and he tries to walk outside when he is alone and less attention is with him."

"My children and I call my elder sister. I think once a week I call them when I feel lonely and bored. And I don't call them more often because I hate to be a burden to them"

"Actually I live with my wife but I feel so alone to be this big house alone without my children. Build my house this big but my children preferred to live independently on their own, so we both live here alone. Sometimes it's so calm in the house. I feel so stressed, so I have my radio on full day."

"Mentally when someone has to stay in one place at once due to a disease it's a disaster. Especially at a young age. I had many problems running in my head when I was taken to the surgery. And it's so lonely when you have to stay at the hospital for months. Even the relations couldn't visit all the time. Therefore it's very lonely."

From a total 29 volunteer participants, 65% of participants stated that they prefer to have someone with them rather than being alone.

"I like to have someone. My one and only son is also abroad. So me and my wife are at home. We both are retired now. I prefer to have someone with me rather than being alone. "
"he enjoys talking face to face. Mainly interested in the history topics, movies and books. So someone needs to be with him"
"I like to have someone. My one and only son is also abroad. So me and my wife are at home. We both are retired now. I prefer to have someone with me rather than being alone. "

From a total 29 volunteer participants, 43% of participants stated that they have issues with management of daily reminding activities like diet handling and medical reminders.
"Remind myself. Have arranged medicines in a box in a way that I can easily pick them. Sometimes I forget."
"Due to loss of short term memory, he always forgets that he ate last moment, and tries to eat again. So I need to remind him."
"I take medicine when I remember it naturally like after having a meal and sometimes my wife reminds me."

Those two studies show that the basic needs of long term patients handling the main issues which need to be addressed by a caretaker are decreasing the loneliness of the patient, proper management of medical/diet reminders and proper management of exercises of patients. Since the elderly people often forget what the reminder asked them to do, it's always better to remind them twice until they confirm that the task has been done.

3.2.2 Suggestion of a tentative design and development of design artifact

The study focused on designing a system architecture to improve long term patients' quality of life phenomena by establishing conversational interfaces in long term patients as well as their caregivers/caretakers in a more valuable manner. Therefore proof of concept development was to design a customized voice-based chatbot application using VIPA for long term patients. The chatbot application consists of functionalities centered specifically for long term patients such as customized small talk, bedridden exercise coaching as well as mind games. Figure C.2 shows the proposed architecture of the voice application. Major requirements identified were loneliness and physical exercise for the long term patients and these parts from the proposed architecture were implemented as the proof of concept using Google home mini and voice assistant. As the conversation design needs to be more situational we used the findings from the analysis and the literature review to select a few interesting areas of the long term patient and the flow of voice agent. The voice agent was developed using developing intents which mainly includes NLP concepts. Researchers used DialogFlow NLP system to develop our voice agent. Researchers used Actions on Google Node.js client library and Firebase cloud functions to build the webhook service to build the fulfillment service to determine the desired intent and to give the proper outcome.
For the development of initial chat data flow we trained the voice agent using a random sample of 3 patients and 8 healthy people. The design was developed using participatory design.

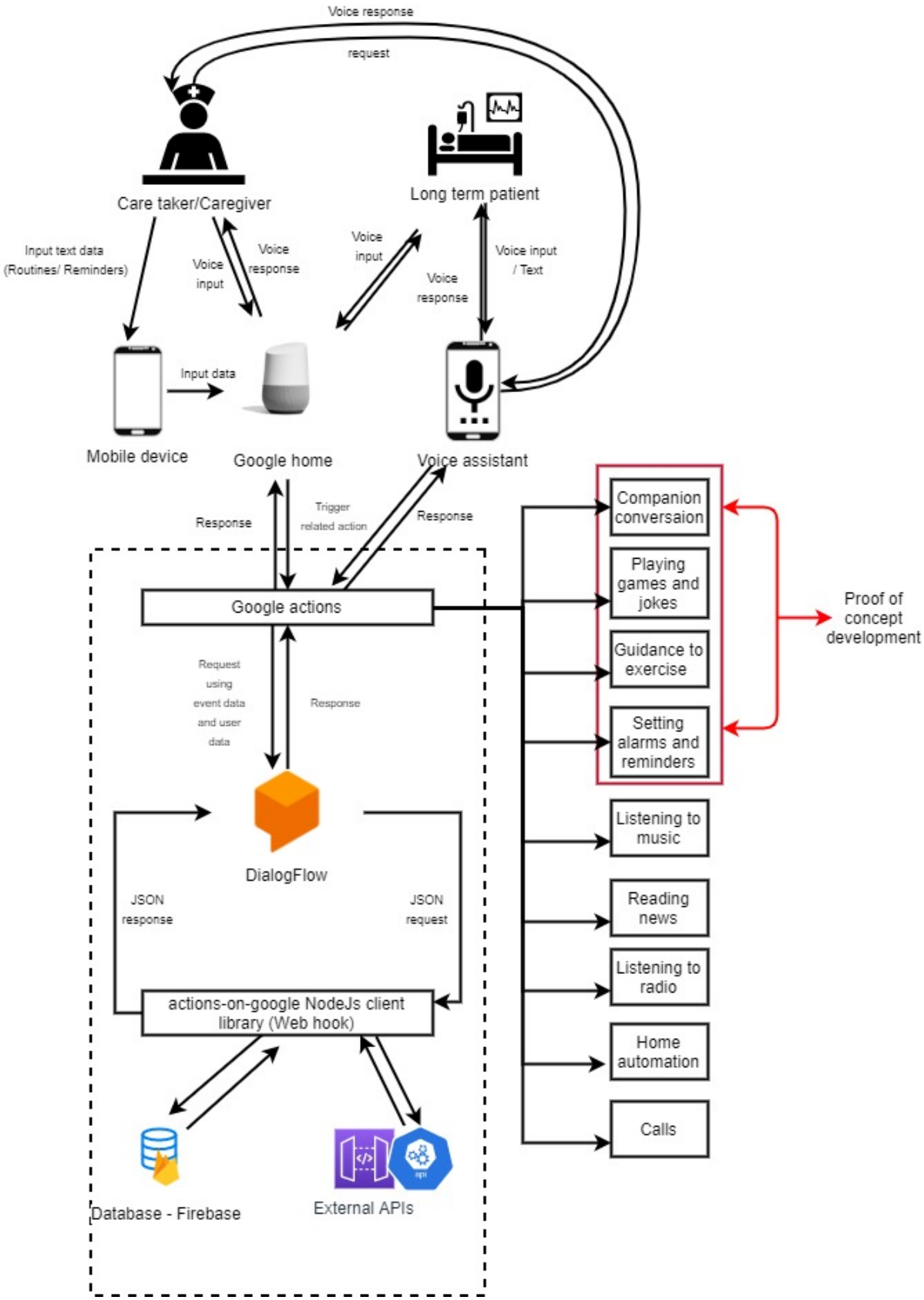

Figure 3.7: Proposed Architecture for the Voice Application

3.2.3 Demonstration and evaluation of the solution

Evaluation of the research was conducted by analyzing user feedback through a qualitative questionnaire obtained from a set of long term patients. The sample for the evaluation is long term patients in Sri Lanka who need immediate care of a caretaker/ caregiver. The selected sample is with different levels of proficiency in technology and backgrounds. And the evaluation process of the conversational chatbot was conducted using Google Home devices and mobile phones among long term patients as well as caretakers/ caregivers to verify the absolute impact of the chatbot. In the evaluation process, the long term patients use the device two times to be familiar with the device because the users are very novel to the voice integrated personal assistance. After the user gets familiar with the device and uses the device for a few rounds we collected their responses using the questionnaire. To conduct the evaluation, researchers select the sample considering many factors. Individuals were selected by considering their; English literacy; meaning selected participants must be able to speak and understand English. This would be the main requirement since the Google home device supports the English language. Technology literacy; as the application and the user device are technological. When it comes to technology literacy the patients do not have to be experts in technology since using the google home device is much easier compared to mobile phones and laptops. They must be enthusiastic to embrace new technology which helps us to get an effective outcome. We consider the Mobility level of the patients because selected participants should be able to follow the exercises. Considering the mobility level they do not have to be an active person. Even bedridden persons are included in the sample with the capability to speak and move hands and legs. To get an understanding of the use of exercise to feature their physical capabilities must be concerned. After allowing the participants to use the application two times a structured questionnaire (Appendix B) was used to collect feedback data and this questionnaire and the use of application administered in the English language. Before giving the application to use and administering the questionnaire, the purpose of this study and the importance of their participation in this study were explained. A simple demonstration was also done. They were allowed to withdraw participating in the study at any time during the administration of the questionnaire. Then a consent letter was given to those patients to get their consent. They were not forced to participate since their participation is voluntary in the research. Some photos and videos of participants engaging with the application were taken from some participants with their consent. The obtained information was kept confidentially and those were only used for the academic purpose of this research.

3.2.4 Communication with related community

The effect of conversational interfaces is communicated to the target community while evaluating the developed voice agent with them. And using feedback from the users for the development, we are planning to improve the design and go through the design science research processes again but due to time constraints, we had to get one iteration of test phase only.

Chapter 4

Implementation

4.1 Chapter Overview

Implementation chapter presents the development of the solution and how it has been conducted. It included the tools used for the development, implementation and testing. Overall idea on the development tools and how those tools have been used contains comprehensively in the development chapter.

4.2 Implementation process

4.2.1 Google Home: How it works

For building and testing the proof of concept for the research, researchers have used Google Home device as the conversational interface. Google provides an API to develop applications for Google home; which is an example of an existing conversational interface that is widely used for day to day household use. Google allows these developed applications for either personal or public usage. Researchers have used this API; Google Actions Console to build and perform customized tasks in Google Home, named “Actions”. Researchers used Dialogflow API, which is a conversational platform used to design and build Actions. It wraps the functionality of the Actions SDK and also provides some more additional features like natural language understanding (NLU) feature, easy-to-use IDE, and machine learning. In Dialogflow, virtual agents are called ‘Agents’, which handle the conversation with the end-users. It can be described as a natural language understanding module used to understand the nuances of human language. Within Agents, there are ‘Action Intents’. Once an Action that is developed in Actions Console is invoked, Action Intents exhibit that something end-user wants to get done and pass to the corresponding Dialogflow agent. The Google home mini device can be customized for the users using different tools available in the Google action. Flashcards are a tool available in the google home mini to develop games. The google action provides a few templates to develop games to play in the google account. Mainly there are three templates such as Flashcards, Trivia games, and Personality Quiz. The three templates have different ways of running the game. In the flashcard templates, we have to insert the

question to be asked by the user. Then the answer also entered into the template. Since the user can give similar answers, all the similar answers have to be inserted into the template and the answers are separated. If the user feels the question is hard we can insert a hint to make it easy. Then the follow up has to be inserted to say after the user gave the answer. The Flashcard template can be used to store many questions to be asked as you wish and in the configuration, we can set the number of questions to be asked in one round and the name for the game. Trivia Game differs from the flashcard game since we have to suggest three answers and the user selects the correct answer from the suggested answers. If there are similar words for the correct answer the same as the flashcards we can insert those answers to the template. Since trivia games suggest three answers to the user there is no hint option. If the user gets wrong it provides the correct answer and moves to the next question. At the end of the quiz, the marks will be given by the Trivia game and asked whether the user likes to play another round. If not the game exit.

4.2.2 Companion conversation voice agent functionality

The conversation was built using user scripting the conversation based on a specific scenario. Conversations are built in a manner where it suits better for a long term patient. As previously analysis findings emphasized that patients most of the time have mood swings moments and caregivers are having a considerable amount of stress due to these occasions. Therefore it is important to have customized voice agents with these kinds of patients. By using this functionality patients can get independent moments, fun times and also less stress to the caretakers.

Here we segregated the flow into three main chat flows such as if the user is sad, happy or default flow for any other moments. Voice agent is trained in a way when the user reply to the voice agent about how he/she feels right now, automatically it can choose the chat path in the training phase with enabled generalization process using NLP. Since we developed the initial flow of the voice agent with the help of 3 healthy people and 2 patients through a participatory design process, we have created chat flow for sad/depressed moment using 3 sub chat flows as well as for when the user is happy, there will be also 2 different chat flows voice agent follows. For the default flow combination of commonly used chat flow has been used. In all these steps the user can terminate the chat at any time which is more convenient for them and they are given considerable waiting time between chat process to reply. Also, the agent repeats the questions if there is any delay in the users' reply. chat flow is shown in Appendix C

The scenario below illustrates(Figure 4.1) is a patient using the voice agent when the user is sad and the user can get in conversation with the voice agent as he wishes and below we have demonstrated the flow of meditation.

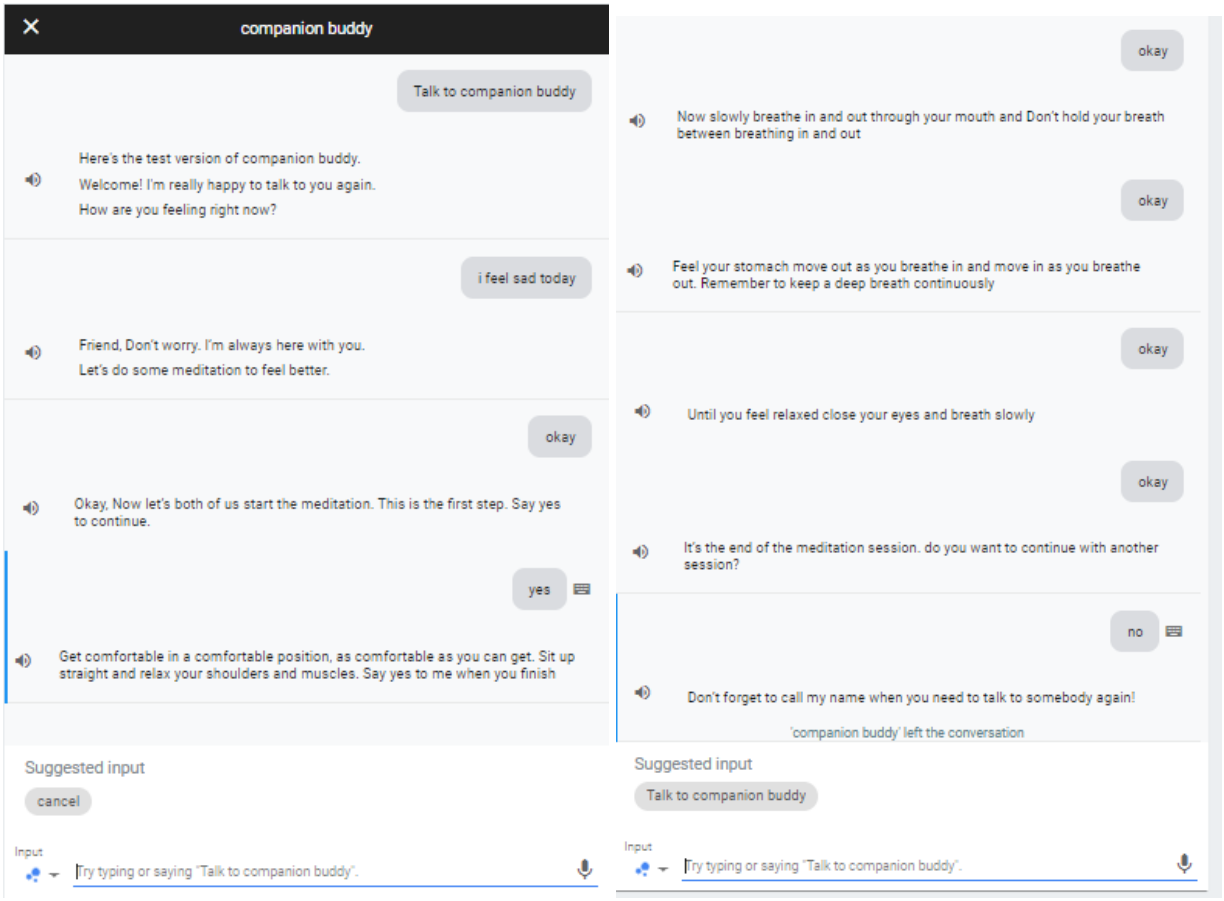

Figure 4.1: Patient Using the Voice Agent

Below given is the algorithm for the companion conversation when user entering sad or happy.

Algorithm 1 Companion conversation chat query flow

function GETUSERFEELING(feeling p_3, userApproval q_3)
    if (p_3 == sad **AND** q_3 == yes) $\leftarrow$ **true then**
        return encouraging welcoming phase
        if (userApproalProcess == yes) **then**
            return the process flow - (meditation session/ other seesion)
        else
            go back to the beginning of current session
    if (p_3 == happy **AND** q_3 == yes) $\leftarrow$ **true then**
        return encouraging welcoming phase
        if (userApproalProcess == yes) **then**
            return the process flow - (gaming session/ other seesion)
        else
            go back to the beginning of current session
    else
        return termination phase

4.2.3 Bedridden Exercises voice agent functionality

Regular physical exercises or activities are very beneficial for everyone, even elderly adults or patients with limited mobility. According to the interview study, 6 participants are engaging in exercises daily. Also, 7 participants have mentioned that they are suffering from muscle pains in the legs, hands or backbones. Seniors or patients who are bedbound need daily exercises for preventing muscle deterioration or atrophy. Daily exercise in the elderly can be helped in different ways such as for relieving stress, improving self-esteem, and reducing depression. As a proof of concept researchers designed and developed an interaction model for bedridden exercises functionality as guidance to perform exercises for bedridden patients and elders. The functionality focuses on regular exercises which can perform while in bed for arm and leg muscles.

Scenario below in Figure 4.2 illustrated is a patient using the voice agent for doing exercises. When a user says talk to daily fitness the agent loads the functionality and it starts.

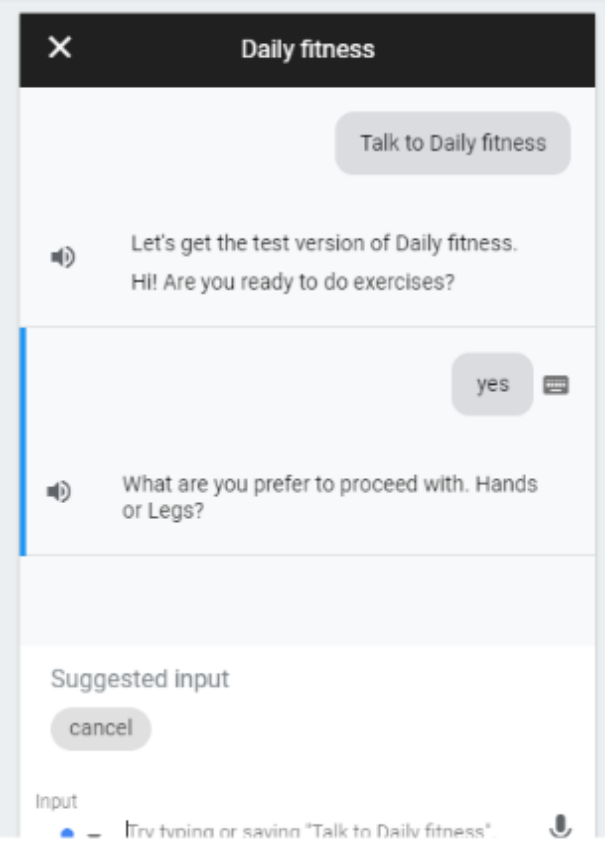

Figure 4.2: Testing Using the Google Assistant

Here in the interaction model, it not only specifies the dialogue between Google Home and the user but also specifies the Action Intent structure and decision handling.

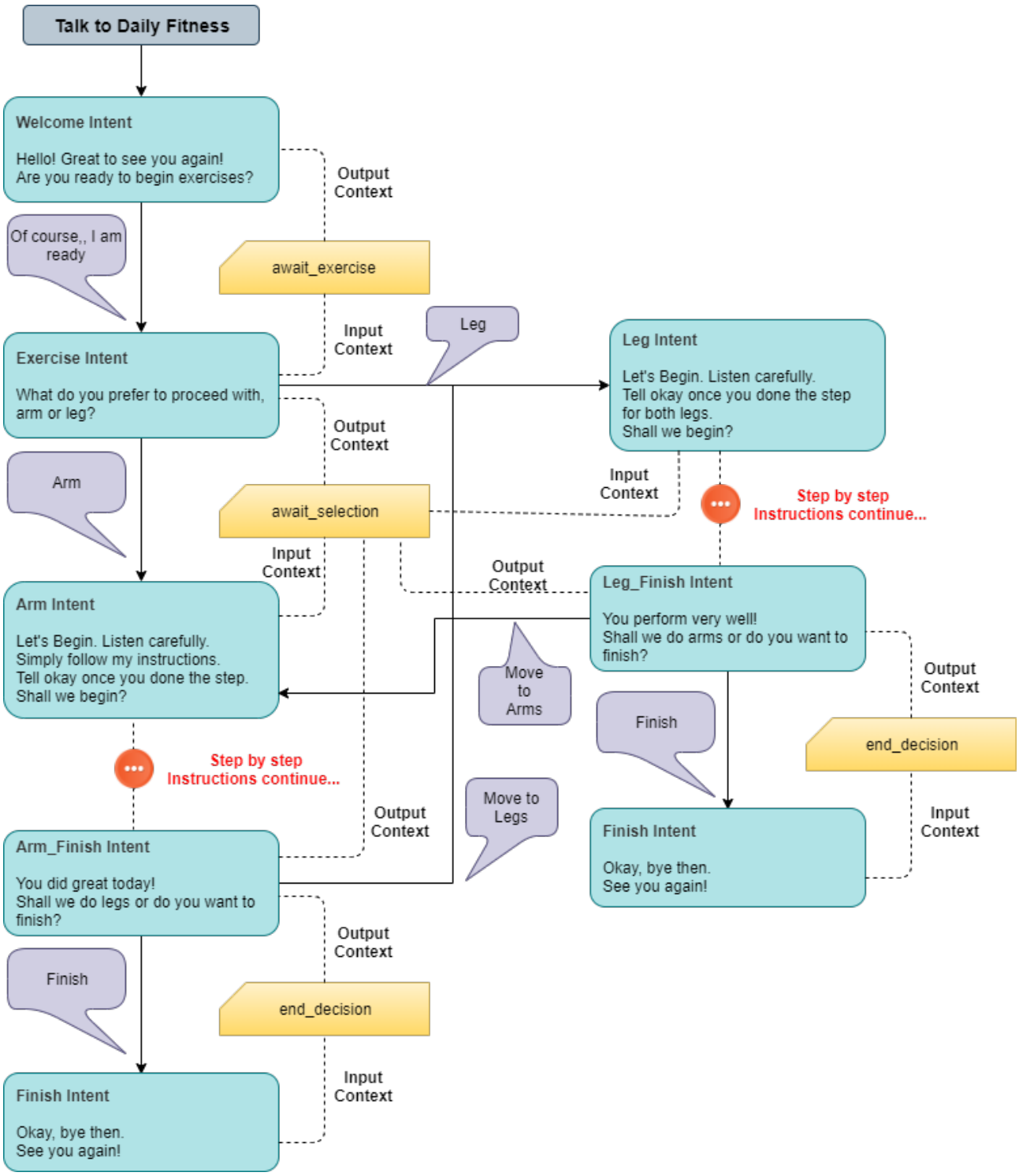

Figure 4.3: Intent Network Flow Chart of Bedridden Exercises Feature

Figure 4.3 is the flowchart that describes the basic idea of the implementation for bedridden exercises feature including user commands, Google Home responses and the interaction between the user and the device. The dashed lines describe the flow between action intents.

4.2.4 Games voice agent functionality

From the conducted requirement gathering, we identified many elderly patients like to play games when they feel bored, even though they cannot use the screen or the conventional input devices to play the games. People tend to play games when they feel bored and to engage them more in an activity. Playing games help their brains to focus on a task and even playing fun quizzes improve their knowledge while making them more joyful. In order to address their needs, we developed Quizzes to play with the Google home mini. Different questions can be inserted as the interest of patients to play when they want to. In the system development, we selected some analytical, general knowledge and funny questions in general. We can add any number of questions and decide how many questions to be asked in one round. The questions are randomly selected by the system. Questions can be customized according to the users interest areas. The below Figures 4.4 shows the testing for the mini quiz game

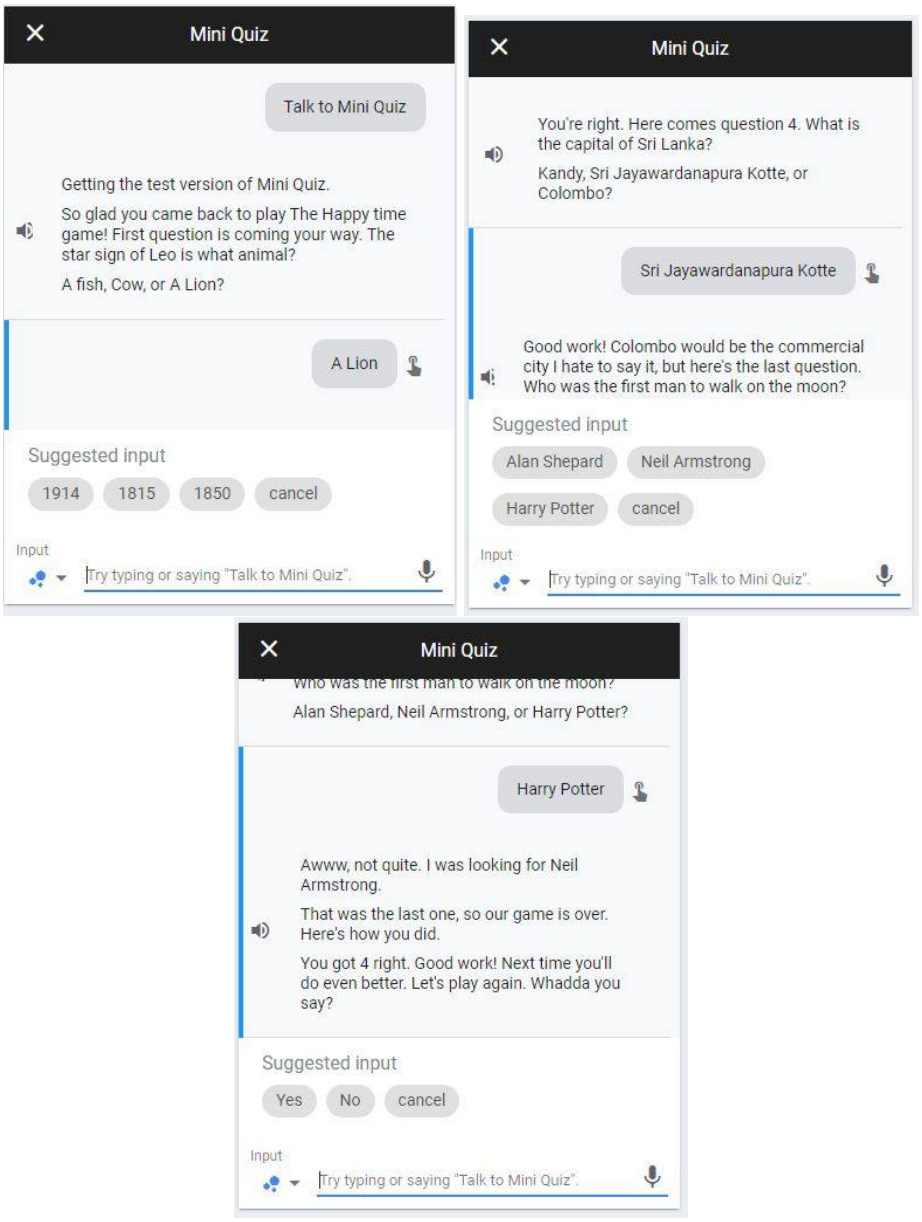

Figure 4.4: Testing for the Mini-Quiz Game

For the implementation, we selected MCQ questions with one correct answer. Then the user can tell the correct answer from the suggested answers. The follow up can be given to the database. The system will count the number of correct answers and finally will tell the marks. If the patient plays many rounds they will get different questions depending on the number of questions in the database. When the patient wishes to play the game simply they can ask "Talk to Dr.Talk" The game will appear. Even Google does the game with the background sounds to keep the player more engaged. When developing the game if the patient tends to give the same answer in different ways we can suggest all the different ways of giving the answer to the database. Since the long term patients can play the game without doing any physical activity it is quite useful for many long term patients.

Google actions have many different types of gaming templates such as Flashcards, Trivia and the personality Quiz. For the development purpose, we used the Trivia template to develop the Questions. The game can be played without the help of the screen. When the question is asked by the speaker it suggests the answers too. From the suggested answers the user can tell the correct answer. If the user uses a synonym, those similar answers must be stored as alternate answers. Otherwise, the speaker could not get the answer provided. Therefore in the training process, we have to identify the similar answers provided by the user and improve the game according to the user. The template can store many questions as the developer wishes. For the research purpose in long term patient care researchers add 30 questions into the template. Thus in the configuration, we can select how many questions to be asked in one round. Then the game will flow according to the number of questions to be asked and the system will randomly select the questions to be asked. At the end of the round, the speaker will count the number of correct answers and will give a score to the user. If the user loves to play another round he can say yes when the speaker asks do you like to play another round. If not the user can say no and exit the game. . Figure 4.5 represents the process diagram of mini quiz game.

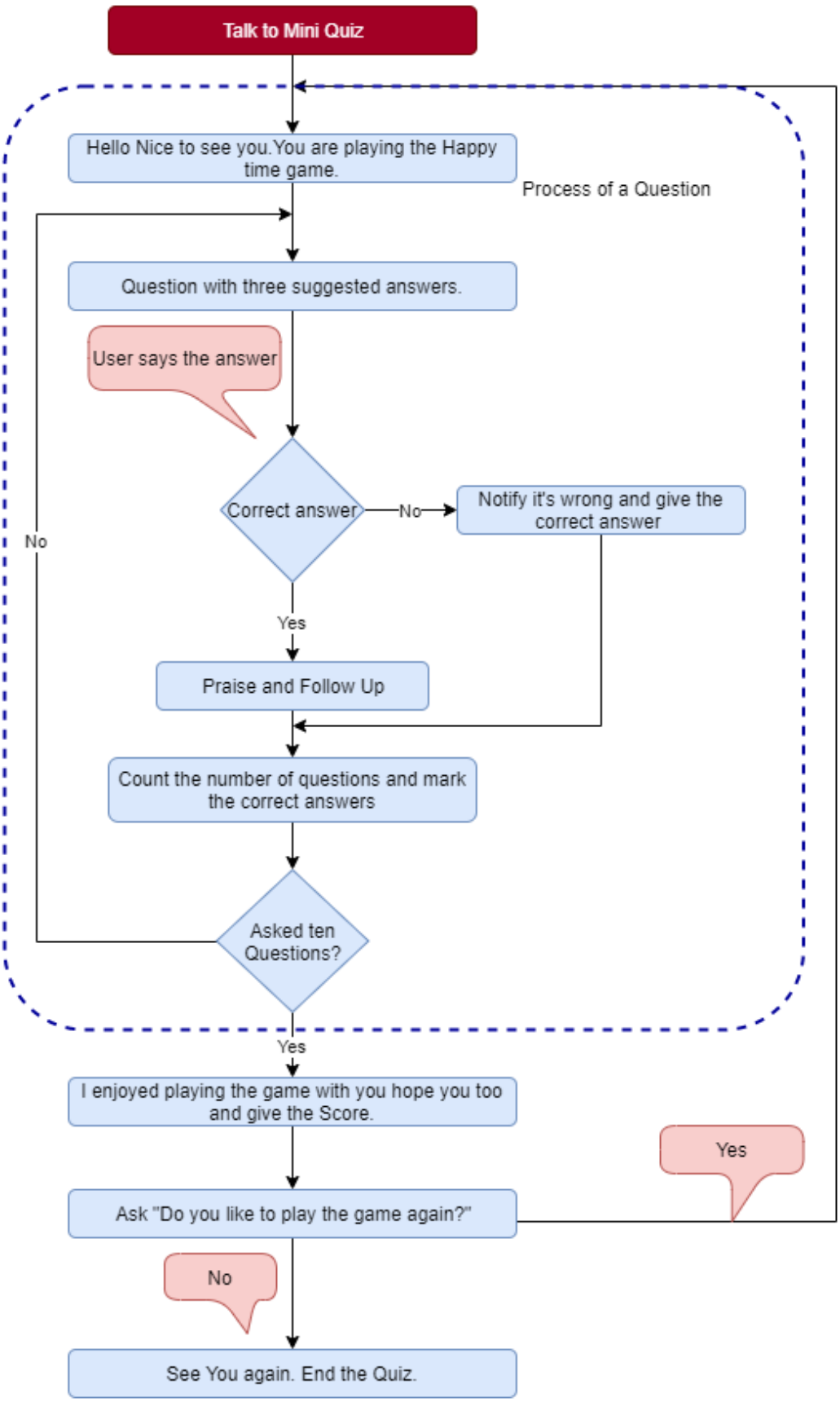

Figure 4.5: Process Diagram of Mini Quiz Game

Chapter 5

Analysis and Results

5.1 Chapter Overview

Analysis and Results chapter includes an analysis for the evaluation of the study. Mainly it describes the result obtaining procedures, how the final outcome calculated, quantitative and qualitative results and how the success of the study is measured. The outcome of the results and the comparisons presented in detail. The chapter reasons the variations and the deviations in the results.

5.2 Analysis and results

According to the first phase of the methodology; awareness of the problem, it identifies that decreasing the loneliness of the patient, proper management of medical/diet reminders and proper management of exercises of patients are the main problems that need to be addressed by a caretaker. Considering those points, initial design and development of the interactive model which displays the part of suggesting architecture as proof of concept have been developed by the researchers. The next step is to take the evaluation by demonstrating the developed interactive model.

As the research is performed in accordance with the design science research method researchers have set up the evaluation criteria for the initial application developed as the first iteration. Here the process of taking feedback has used a mixed approach as mentioned in the research approach meaning both qualitative and quantitative feedback were taken. The participatory design approach was used because the development is done with user participation. Feedback and evaluation taken by long term elderly patients who are the end-users and the results and feedback were analyzed to design the next iteration.

Before going to the actual iteration a training iteration was carried out by participating a few healthy participants and few patients by giving them to use the application. 2 patients and 3 colleagues participated in the training iteration. Their feedback was taken and researchers improved the initial application according to them. The Following are the summary of the improvements made in accordance with the training iteration.

1. Instructions made as shorter steps in bedridden exercises voice agent.
2. Conversations made clearer in companion voice agent.
3. Included questions matching with local context in the game voice agent.
4. Made conversations more user-friendly.
5. Added more training phases for conversations.

After the test iteration, the first iteration took place involving actual users. The sample for taking results was a group of elderly patients aged between 60 to 95 who suffer from long-running illnesses and who live in a home environment in Sri Lanka. The sample size was 11. Individuals were selected by considering their,

1. English literacy; meaning selected participants must be able to speak and understand English
2. Mobility level; because selected participants should be able to follow the exercises.
3. Technology literacy; because the application and device used are technological.

After allowing the participants to use the application two times a structured questionnaire (Appendix B) was used to collect feedback data and this questionnaire and the use of application administered in the English language. Before giving the application to use and administering the questionnaire, the purpose of this study and the importance of their participation in this study were explained. A simple demonstration was also done. They were allowed to withdraw participating in the study at any time during the administration of the questionnaire. Then a consent letter was given to those patients to get their consent. They were not forced to participate since their participation is voluntary in the research. Some photos and videos of participants engaging with the application were taken from some participants with their consent. The obtained information was kept confidentially and those were only used for the academic purpose of this research.

Obtaining results were performed under seven categories as follows.

- General Information
- Literacy Level
- Google Home Device
- Mind Game Feature
- Bedridden Exercises Feature
- Talking Companion Feature
- Overall Conclusion

As general information gender, age, mobility level, disabilities and diseases were recorded. Literacy level was concerned with technical literacy and English language literacy. Other than that information, Feedback on Google Home Device, Mind Game Feature, Bedridden Exercises Feature, Talking Companion Feature and satisfaction as overall were collected from subfactors through the structured questionnaire (Appendix B). Each feedback on google home device, feedback on mind game feature and feedback on bedridden exercises feature were divided into seven subfactors. Feedback on talking companion feature was divided into four subfactors and feedback as the conclusion were divided into nine subfactors. Five-point Likert scale (Table 5.1) was used to measure and rate each subfactor in the scale.

Table 5.1: Likert Scale and Rates

Measure	**Rate**
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly Agree	5

Data Analysis was done using SPSS (version 27) software. Total Satisfaction of each participant was taken as the final outcome. For calculating total satisfaction five factors were considered;
Factor 1: Google Home Device
Factor 2: Mind Game Feature
Factor 3: Bedridden Exercises Feature
Factor 4: Talking Companion Feature
Factor 5: Overall Conclusion

Total satisfaction of each participant for the evaluation model is presented through the final outcome and it is ranged between 0 and 1. Equal weights were taken for the five factors when calculating the total satisfaction and calculation is done using the following equation (Figure 5.1).

$$S_{\text{Total}} = \frac{\sum_{k=1}^{n} r_k}{n * \text{R}}$$

Figure 5.1: Equation

S_{Total} displays total satisfaction where n indicates the number of total subfactors. r_k indicates the rate given for the k^{th} subfactor and R indicates the maximum value in rating scale. The same

equation has been used for calculating satisfaction for a factor separately. There, n should be the number of subfactors only relevant for that particular factor.

Based on the values derived from this equation, we were able to compare each of these five factors in terms of satisfaction. This calculation used to quantify the satisfaction as by considering it as an entity capable of being measured. We used conservative threshold of 0.75 (75%) for S_{Total} value derived from the equation for each participant to quantify the success of the research.

5.3 General Information and Literacy Level

According to the analysis, most of the participants were females(54.5%) while the percentage of male participants was 45.5. Majority of participants were within the age group of 70 - 79 years (36.4%) and 27.3% percent of participants were aged between 80 - 89 years old. Percentage of age group 60 - 69 years and percentage of age above 90 years were 18.2. Of all the participants 54.5% had heart diseases and 18.2% had diabetic. One participant had Parkinson disease and 27.3% had other diseases rather than those. Majority of participants (72.7%) had vision disabilities while 63.6% had mobility issues. More information on following Table 5.2.

Table 5.2: Characteristics of the Sample

Participant ID	**Age**	**Gender**	**Disease**	**Disabilities**
1	85	Male	Parkinson	Disabilities due to Parkinson
2	80	Female	Thyroid, Knee joint pain	vision, mobility
3	95	Female	Heart disease, partial memory loss	vision, mobility
4	75	Male		vision, mobility
5	74	Male		vision, mobility
6	71	Male		vision, mobility
7	83	Female	Heart disease	vision, mobility
8	94	Female	Heart disease, Knee joint pains	
9	60	Female	Heart disease	
10	65	Male	Heart disease, Diabetic	vision
11	74	Female	Heart disease, Diabetic	vision, mobility

According to the descriptive analysis (Table 5.3) almost all participants had good or very good English literacy level (100%). In terms of technology literacy, only 18.2% of participants had good technology literacy and no participant (0%) was very good in technology literacy however 45.5%, 27.3% and 9% of participants had medium, poor and very poor technology literacy respectively. When considering mobility level most of the participants (45.5%) were not very active and did

their work with someone's help and 18.2% of participants quite active but often in one place while 27.3% were somewhat active that can manage their work.

Table 5.3: Mobility levels and literacy levels of the sample

Variable	**Category**	**Percentage**
Mobility	I am a bedridden person. I rarely walk.	0
	I am not very active, but I can walk or manage to do some work with someone's help.	45.5
	I'm quite active, but often I'm in one place.	18.2
	I am a somewhat active person. I can manage to do some work	27.3
	Even though I have an illness. I am an active person.	9
English Literacy	Very Poor	0
	Poor	0
	Medium	0
	Good	63.6
	Very Good	36.4
Technology Literacy	Very Poor	9
	Poor	27.3
	Medium	45.5
	Good	18.2
	Very Good	0

5.4 Google Home Device

The first subfactor; Wake up the device is easy, was rated on average 4.27 (SD=0.786) having responded as strongly agree (N=5;45.5%), agree (N=4;36.4%) and neutral(N=2;18.2%). Selecting the feature is easy, was rated on average 3.91(SD=0.701) having responded as strongly agree (N=2;18.2%), agree (N=6;54.5%) and neutral(N=3;27.3%). Most responses (N=8;72.7%) strongly agree with the fact that the sound is clear on average of 4.64 (SD=0.674) while N=2 and N=1 responses indicate agree and neutral respectively. Majority (N=7; 63.6%) confirms that the Language is understandable by strongly agreeing and N=3 agrees for that while N=1(9.1%) has disagreed for the same. That was rated on average of 4.45 (SD=0.934).

Only one respondent disagreed with the fact that talking to the device rather than typing or pressing buttons is helpful/good/easy while N=3 and N=7(63.6%) shows neutral and strongly agree for the fact respectively. That was rated on average of 4.18 (SD=1.168). 54.5% respondents(N=6)

strongly agreed to keep a device like that with them while 27.3% (N=3) agreed and N=1 responded as both neutral and disagree. That was rated on average of 4.27 (SD=1.009). For the final subfactor; I can use such a device as a caretaker, most of the responses (N=6;54.5%) were disagree while 18.2% (N=2) shows neutral and N=1 response for each strongly disagrees, agree and strongly agree were there. That was rated on average of 2.25 (SD=1.128). See Table 5.4.

By looking at the results we can see most participants like to have such a device with them but they do not think that the caretaker can be replaced by such a device because the device cannot provide physical support for the patients. They prefer to have conversational interfaces rather than typing or pressing buttons. Also, the device controlling such as wake up and selecting features is easy for them. Same time the sound and language are clear and understandable for patients like them.

Table 5.4: Descriptive analysis on Google Home Device

Factor: Google Home Device							
Sub Factors	**Number of Responses**	**Range**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
Wake up the device is easy	11	2	3	5	4.27	0.786	0.618
Selecting a feature is easy	11	2	3	5	3.91	0.701	0.491
Sound is clear	11	2	3	5	4.64	0.674	0.455
Language is understandable	11	3	2	5	4.45	0.934	0.873
Talking to the device rather than typing or pressing buttons is helpful/good/easy	11	3	2	5	4.18	1.168	1.364
I like to keep a device like this with me	11	3	2	5	4.27	1.009	1.018
I can use such a device as a caretaker	11	4	1	5	2.55	1.128	1.273
Valid Responses	11						

5.5 Mind Game Feature

The first subfactor for mind game; I enjoy the game, was rated on average 3.91 (SD=0.831) having responded as strongly agree (N=3;27.3%), agree (N=4;36.4%) and neutral(N=4;36.4%). Game

is helpful when I feel lonely, was rated on average 3.73(SD=0.786) having responded as strongly agree (N=2;18.2%), agree (N=4;36.4%) and neutral(N=5;45.5%). Most responses (N=4;36.4%) were for both agree and neutral with the fact that game identifies answers correctly on average of 3.64 (SD=0.924) while N=2 and N=1 responses indicate strongly agree and disagree respectively. Majority (N=6; 54.5%) shows neutral when it comes to understanding the questions. N=2 was for both agree and strongly agree while N=1(9.1%) has disagreed and the fact was rated on average 3.45 (SD=0.934).

The fact; the game is useful to me, was rated on average 3.64 (SD=0.809) having responded as neutral (N=6; 54.5%), agree (N=3;27.3%) and strongly agree (N=2;18.2%). Majority (N=7; 63.6%) confirms that they feel engaging in the game by strongly agreeing also N=3 agrees and N=1(9.1%) shows neutral about that. That was rated on average of 4.55 (SD=0.688). Fact; often feel like playing the game, was rated on average 3.64(SD=1.362) having responded as strongly agree and disagree (N=4;36.4%) and agree(N=3;27.3%).See Table 5.5.

By looking at the results we can see most participants mostly agree that they can engage in the game as they think they can enjoy the game and the game is helpful to avoid loneliness. But sometimes they had difficulty understanding the questions in the game. That problem needs to be addressed in the next iteration of the design science process. And at the same time game should be developed in a way to identify the user responds effectively. Long term patients mostly prefer to have a feature such as mind games especially for spending their time and enjoying life. So they often feel like playing such a game.

Table 5.5: Descriptive analysis on Mind Game Feature

Factor: Google Home Device							
Sub Factors	**Number of Responses**	**Range**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
I enjoy the game	11	2	3	5	3.91	0.831	0.691
Game is helpful when I feel lonely	11	2	3	5	3.73	0.786	0.618
Game identify my answers correctly	11	3	2	5	3.64	0.924	0.855
I understand the questions	11	3	2	5	3.45	0.934	0.873
Game is useful to me	11	2	3	5	3.64	0.809	0.655
I feel engaging in the game	11	2	3	5	4.55	0.688	0.473
Do you often feel like playing the game	11	3	2	5	3.64	1.362	1.855
Valid Responses	11						

5.6 Bedridden Exercises Feature

The first subfactor for bedridden exercises; easy to wake up the feature, was rated on average 4.82 (SD=0.405) having responded as strongly agree (N=9;81.8%) and agree (N=2;18.2%). Instructions are clear, was rated on average 4.64(SD=0.505) strongly agree (N=7; 63.6%) and agree (N=4;36.4%). The fact;it identifies responses clearly, was rated on average 4.64(SD=0.505) strongly agree (N=7; 63.6%) and agree (N=4;36.4%). Most responses (N=7; 63.6%) were for strongly agree for the fact that they enjoy engaging in daily fitness on average of 4.55 (SD=0.688) while N=3 and N=1 responses indicate agree and neutral respectively. Majority (N=7; 63.6%) strongly agree when it comes to the fact that it is a great help for doing exercises while N=3 and N=1 responses indicate agree and disagree respectively and the fact was rated on average 4.45 (SD=0.688).

The fact; it can be used to gain my mobility, was rated on average 3.91 (SD=1.221) having responded as neutral (N=2;18.2%), agree (N=4;36.4%), strongly agree (N=1;9.1%) and strongly disagree (N=4;36.4%). Majority (N=6; 54.5%) confirms that they like to have this feature by strongly agreeing also N=3 agrees and N=1(9.1%) shows both neutral and disagree about that. That was rated on average of 4.27 (SD=1.009). See Table 5.6.

Almost all participants liked to have the bedridden exercises feature for them. It was easy to

use by the patients. They preferred to use the feature daily. But they do not think the feature can be used to gain their mobility again as there the most patients are older adults so there is an age barrier to gain mobility back. They can do daily exercises with proper guidance by using the feature easily while they are in bed.

Table 5.6: Descriptive analysis on Bedridden Exercises Feature

Factor: Google Home Device							
Sub Factors	**Number of Responses**	**Range**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
Easy to wake up the feature	11	1	4	5	4.82	0.405	0.164
Instructions are clear	11	1	4	5	4.64	0.505	0.255
It identifies my responses clearly	11	1	4	5	4.64	0.505	0.255
I enjoy engaging in daily fitness	11	2	3	5	4.55	0.688	0.473
It is a great help for doing exercises	11	3	2	5	4.45	0.934	0.873
It can be used to gain my mobility	11	4	1	5	3.91	1.221	1.491
I like to have this feature	11	3	2	5	4.27	1.009	1.018
Valid Responses	11						

5.7 Talking Companion Feature

The first subfactor for talking companion; this will help me when I'm bored and lonely, was rated on average 3.73 (SD=1.191) having responded as strongly agree (N=3;27.3%), agree (N=4;36.4%), neutral (N=3;27.3%) and strongly disagree (N=1;9.1%). This helps them to freshen the mind, was rated on average 3.91(SD=0.701) strongly agree (N=2;18.2%), agree (N=6; 54.5%) and neutral (N=3;27.3%). The fact; they felt like talking to a friend, was rated on average 4.09(SD=0.831) having responded as agree (N=7; 63.6%), strongly agree (N=3;27.3%) and disagree (N=4;36.4%). Fact; that will make them more independent, was rated on average 3.55(SD=0.820) having responded as strongly agree and disagree (N=1;9.1%), neutral (N=4;36.4%) and agree (N=5;45.5%). See Table 5.7.

Participants mostly agree to the fact they feel as if they are talking to a friend while using the talking companion feature through a conversational interface. So they think the device makes them more independent in their day to day life. They have a companion they can talk while they are in

bed, especially when they feel alone. The feature can be used to refresh their memory as they can spend time talking with the conversational interface.

Table 5.7: Descriptive analysis on Talking Companion Feature

Factor: Google Home Device							
Sub Factors	**Number of Responses**	**Range**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
I think this will help me when I'm bored and lonely	11	4	1	5	3.73	1.191	1.418
I feel this helps me to fresh my mind	11	2	3	5	3.91	0.701	0.491
I felt like I was talking to a friend	11	3	2	5	4.09	0.831	0.691
I think this will make me more independent	11	3	2	5	3.55	0.820	0.673
Valid Responses	11						

5.8 Overall Conclusion

Majority (N=8; 72.7%) have confirmed that it helps to enjoy life, even though they are patient by strongly agreeing while N=1 voted for each agrees, neutral and disagree having an average of 4.45 (SD=1.036). Fact;it is good to pass the time was rated on average 4.73(SD=0.467) having responded as agree (N=3;27.3%) and strongly agree (N=8; 72.7%). It's good for their loneliness was rated on average 4.73(SD=0.467) having responded as agree (N=3;27.3%) and strongly agree (N=8; 72.7%). It is a great help for their daily activities, was rated on average 3.18(SD=0.874) having responded as strongly agree(N=1;9.1%), agree(N=2;18.2%), neutral(N=6; 54.5%) and disagree (N=2;18.2%).

I feel independent when using was rated on average 3.27(SD=1.104) having responded as strongly agree(N=2;18.2%), agree(N=2;18.2%), neutral(N=4;36.4%) and disagree (N=3;27.3%). Most responses show that it is like a companion. That was rated on average 4.27(SD=0.467) having responded as strongly agree (N=3;27.3%) and agree(N=8; 72.7%). The point; as a patient, it is really a helpful technological device for them was rated on average 3.09(SD=0.539) having responded as agree(N=2;18.2%), neutral(N=8; 72.7%) and disagree(N=1;9.1%).

Results show that they like to have this device with them as the fact was rated on average 4.45(SD=0.820) with responses strongly agree (N=7; 63.6%), agree (N=2;18.2%) and neutral

(N=2;18.2%). Most of them like to recommend this device to a person like them because it was rated on average 4.27(SD=1.009) with the responses as strongly agree(N=6; 54.5%), agree (N=3;27.3%), neutral(N=1;9.1%) and disagree(N=1;9.1%). See Table 5.8.

The majority of participants like to have a conversational interface with them and they recommend the device to long term patients who are in the same place for a long period of time such as them. They confirm that it is helpful to enjoy their life even though they are patients. The device is useful to pass the time and to reduce loneliness as it is like a companion for them. So they feel independent by using the conversational interface.

Table 5.8: Descriptive analysis on Overall Conclusion

Factor: Google Home Device							
Sub Factors	**Number of Responses**	**Range**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
It helps to enjoy my life, even though I'm a patient	11	3	2	5	4.45	1.036	1.073
It is good to pass the time	11	1	4	5	4.73	0.467	0.218
It's good for my loneliness	11	1	4	5	4.73	0.467	0.218
It is a great help for my daily activities	11	3	2	5	3.18	0.874	0.764
I feel independent when using	11	3	2	5	3.27	1.104	1.218
It is like a companion	11	1	4	5	4.27	0.467	0.218
As a patient, It is really a helpful technological device for me	11	2	2	4	3.09	0.539	0.291
I like to have this device with me	11	2	3	5	4.45	0.820	0.673
I recommend this device to a person like me	11	3	2	5	4.27	1.009	1.018
Valid Responses	11						

5.9 Quantitative Results Analysis

Satisfaction for every five factors and total satisfaction was calculated against each participant as shown in Table 5.9 and Figure 5.2. Rated values for each subfactor by each participant were used to calculate the satisfaction levels.

Sg - Satisfaction on Google Home device

Sm - Satisfaction on mind game feature

Se - Satisfaction on bedridden exercises feature

St - Satisfaction on talking companion feature

Sc - Satisfaction as the overall conclusion

Stotal - Total satisfaction

Table 5.9: Satisfaction of each participant

ID	Sg	Sm	Se	St	Sc	Stotal
1	0.77	0.77	1	0.7	0.87	0.84
2	0.66	0.77	0.97	0.6	0.69	0.75
3	0.83	0.71	0.94	0.75	0.82	0.82
4	0.86	0.69	1	0.65	0.8	0.81
5	0.86	0.66	0.83	0.95	0.87	0.82
6	0.83	0.71	0.94	0.85	0.87	0.84
7	0.83	0.63	0.89	0.65	0.71	0.75
8	0.83	0.86	0.86	0.95	0.96	0.89
9	0.8	0.97	0.69	0.75	0.73	0.79
10	0.91	0.94	0.94	0.8	0.89	0.91
11	0.71	0.63	0.77	0.75	0.71	0.71

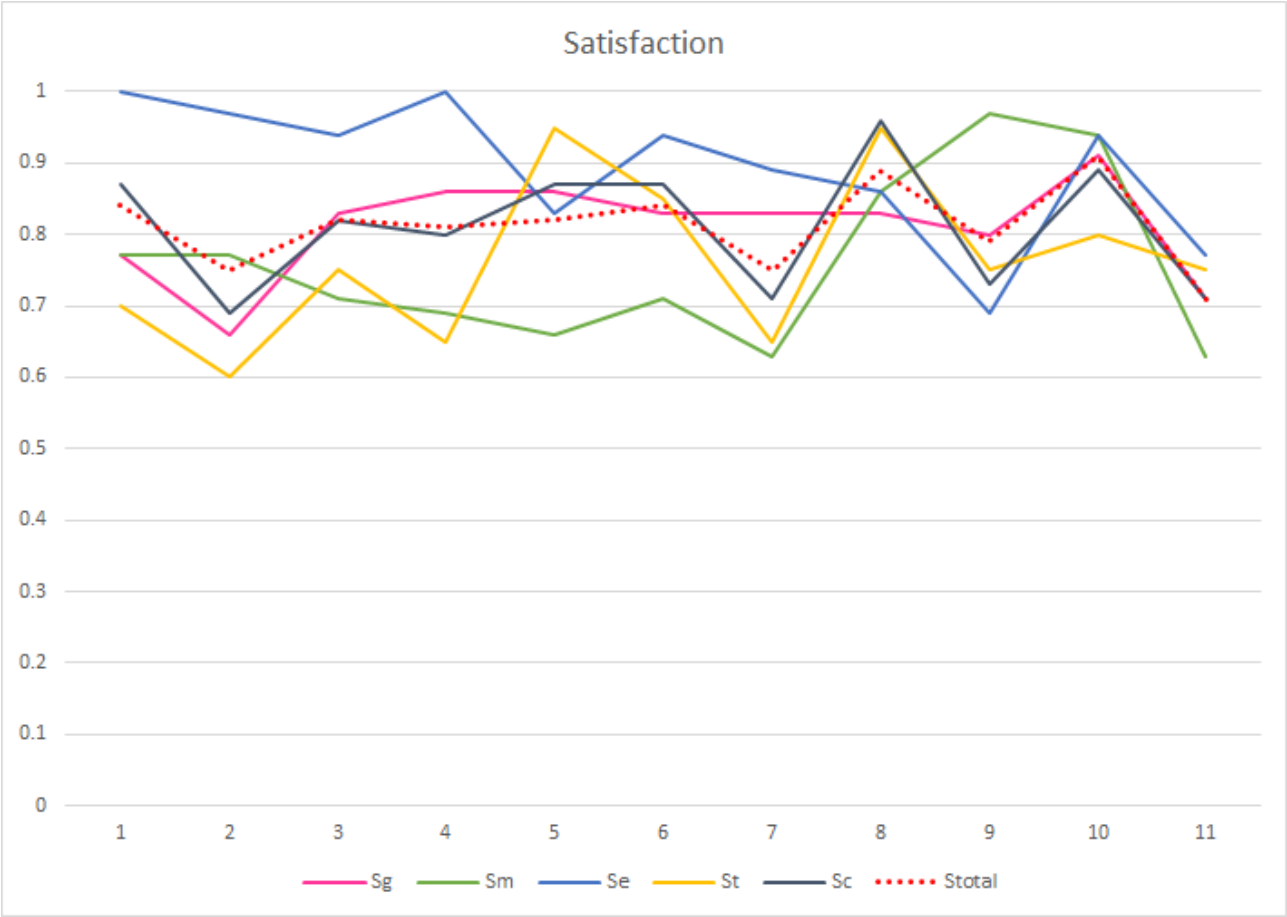

Figure 5.2: Satisfaction of each participant

For satisfaction on Google Home device (Sg) Other than participant number 2 and 11 all participants show a satisfaction more than threshold of 0.75. It indicates 81.82% percent of success. For satisfaction on mind game feature (Sm) Only participant number 1, 2,8,9 and 10 show a satisfaction more than threshold of 0.75. It indicates 45.45% percent of success. For satisfaction on bedridden exercises feature (Se) Only participant 9 shows a less satisfaction level than the threshold, all participants except 9 show a satisfaction more than threshold. It indicates 90.9% percent of success.For satisfaction on talking companion feature (St) Other than participant numbers 1,2,4 and 7 other participants show a satisfaction more than the threshold. It indicates 63.64% percent of success. For satisfaction as the overall conclusion (St) Other than participant numbers 2,7,9 and 11 other participants show a satisfaction more than the threshold. It indicates 63.64% percent of success.

Mainly, the success of the research was measured using the final outcome which is total satisfaction (Stotal). That was derived using subfactors of five factors by giving equal weights to each five factor. For the total satisfaction almost all participants except participant number 11 show satisfaction more than the conservative threshold of 0.75. It indicates 90.9% percent of success of the implemented solution for the research problem.

5.10 Qualitative Results

In the evaluation process, researchers conduct both quantitative and qualitative evaluation. In the qualitative feedback the elderly patients provided their opinion on the voice integrated personal assistant. Below shows the ideas given by them from the experience they had with the device.

Bedridden exercises:
"I think features are good for elders like my parents. But i think it's better to have some encourages phases to add at each step"
"It is good if there is a option to turn on music while doing exercises"

Medical Reminders:
"It's good to have a medical reminder like this. It's very effective. I felt like someone was beside me. Before i always forgot to take medicines and i took whenever i remember about those medicines"

Mind Game:
"I can't understand some of questions in mind game"
"I can play mind game until I sleep"
"Mind games better to play when I am bored"

Overall Product and Device:
"The device cannot recognize my words, Therefore it's difficult to communicate with it"
"If I use the product more, I feel that I can use it more effectively"
"Sometimes I have to listen twice to understand what the speaker said"
"Smart Speaker is great to assist our daily life. I can spend my time more happily and I feel more complete because life is easy."

Since there are not many qualitative results obtained, qualitative results analysis was manually done by researchers. Collected feedback fell into four categories as Bedridden exercises, Medical reminders, Mind game and overall product and device. Some of the feedback was positive while some were negative. Some of them contain suggestions to improve the interactive model in the next iteration.

Chapter 6

Discussion, Conclusion and Future Works

6.1 Chapter Overview

The Discussion, Conclusion and Future Works chapter provides a detailed analysis of the results obtained from the research, constraints, limitations faced during the research, final conclusion and the future works of the research. The chapter reasons the overall outcome of the research.

6.2 Discussion

6.2.1 Discussion on the methodology

The selection of the research methodology is a crucial step in the research, Since research addresses a social problem it is very important to select a suitable research approach to get the maximum result. To conduct the research, Design science research methodology was selected. The methodology clearly explains how to identify the social problem and to gather requirements. Design science research is an iterative approach. Based on the research period we focused on one iteration, where the evaluation is done on the solution developed only based on one requirement analysis. Using the concepts researches created the design science research to conduct the research. As the first step awareness of the problem and literature research, the review analysis and the literature review is conducted. The next step is the suggestion of an initial design and development of design artifact where researchers develop the design and proof of concept. Next demonstration and evaluation of the solution to gain feedback and evaluation on the target group of users. From the comprehensive feedback, we can identify the areas where we need more development. Finally, the solution is to communicate with related communities. Since we targeted single iteration researchers test the proof of concept and evaluated the solution.

6.2.2 Discussion on the scope

The research was conducted to address the issues of long term patients. However, during the research period researchers identified the vast number of requirements of the long term patients.

These requirements can be categorized mainly by the age of long term patients. Therefore, we mainly consider the requirements of the elderly long term patients. During the period we identified there are different types of patients in the long term patient care domain. Mainly in Sri Lanka, those young people who lost their hands and legs due to war or any other accidents would love this type of device. Since most young people have the technology and English literacy the solution would be more useful. Due to the time and other limitations we only focused on elderly patients who live with their families. Therefore the research is mainly focused on elderly patients and their requirements.

In the interview, most of the long term patients suggested having reminders in the smart speaker. One of the major problems in setting reminders was that the device could not invoke itself. In the process of developing the feature, we identified the feature is already built for the selected countries. After setting up the device properly using publicly available firmware version we were able to set medication, diet, meeting, any other type of reminders in the device. And the device invokes itself to give the reminder.

6.2.3 Discussion on the evaluation

For the evaluation process, we used both quantitative and qualitative data gathering methods to identify the significance of the change. By using Likert scale questions we get feedback from the users on the device, mind games, exercises, and the talking companion. In the evaluation, users can rate their satisfaction with the product. Since it's a modern technology with low user experience gaining qualitative data would be troublesome while it's not sensible. Therefore, we collected qualitative data from the people who like to share their experiences on the device. However, mainly we targeted the Likert scale ratings provided by the users to evaluate the results based on the defined criteria. Patients gave both positive and negative responses to the evaluation. Considering the average responses of the patients we selected a benchmark to analyze the results. Researchers used a conservative threshold of 0.75 for STotal value derived from the equation (Figure 4.1) for each participant to quantify the success of the research.

From the initial evaluation results on the device, we can observe the suitability of the device to the long term patients. In the initial table researchers examine the adaptability of the long term patients for the voice integrated personal assistance. The majority of the Sri Lankans native language is Sinhala. Some long term patients face difficulties when understanding the language and getting used to the accent. Half of the sample patients said, "Speaker speaks too fast". Since the sample uses the device for a few hours they get used to the language. Therefore, 63.6% of patients accepted the language is understandable. Since the patients are fluent in English. They knew how to respond. Even Though getting used to the accent was an issue faced by them. Due to the American accent of the google home device, most of the patients said we cannot understand what it says in a single time. In the initial evaluation category, the lowest mean can be seen in "I can use such a device as a caretaker" which is 2.55. The results show that many long term patients disagree on the idea of using it as the caretaker. In the long term patient care domain they expect more caring from a human. They want someone who can understand themselves

easily like a human. Therefore the research results state that the long term patients do not like to substitute caretakers from the voice integrated personal assistance while they consider the device as additional support to the caretaker.

Moreover, the results show the elderly long term patients have the capability to use the google speaker and get the advantage of it. In the analysis, it shows more positive results on the patient ability to invoke the features, interest to use the device and the convenience they gain from using the device other than using mobile phones for communication purposes.

Moving to the use of games, the research evaluates the enjoyability, understandability, and ability of the speaker to recognize the answers given by the user. Overall, we can identify the users who have fairly positive opinions on the game. They highly agreed the game is very engaging. Since the users get more time to use the game "Quiz Girl" (name of the mind game) before collecting feedback they are able to learn how to invoke the game and to select answers. Even Though the speaker had some issues of identifying the answers given by the patients. Since some elderly people face difficulties speaking clearly, the speaker could not recognize the few answers given by patients. When considering the variances of the responses, there is very low variance, which shows the patients show very similar ideas on the questions. In understanding the questions the average rate is about 3.45 which is low compared with the benchmark. This is mainly due to the accent and some questions are not familiar to the patients. This can be improved by customizing the questions based on the interests of the patients. Due to language barriers some patients could not understand the long questions and the suggested answers properly. This may lead to a low rate of understanding while other evaluated criteria got positive responses.

When discussing with the long term patients, most of them like to watch TV when they have free time. They accept playing these games would be a whole new experience. Elderly people who are concerned about the general knowledge love to play the game and they feel more enthusiastic to try many rounds. When considering the understandability, in general, the patients had to ask many times to understand the questions. Most of the patients could not get the idea of the question in the first round and asked several times to understand the question. When answering, some patients are able to guess the answers correctly. Since the questions can be customized based on the user, inserting familiar questions to the user makes them more engaging to the game. They strongly agree with the fact that the game is very engaging and useful when they are lonely. Most of them mentioned playing brain teasers are much better than watching TV or sleeping.

Nevertheless, Exercise guidance developed to the elderly patients shows a very positive response from the users. Long term patients believe that the lack of exercise leads to joint stiffness.. Therefore they face many difficulties in their day to day life. Even due to lack of exercise guidance is a major issue. There can be different tutorials available, but selecting the most suitable exercises is a challenge to the caretaker. The caretaker should always help them to do the exercises while guiding them to do it correctly. Therefore they believe that exercise guidance is very useful. Usually people get bored when doing exercise when it is not very engaging. Even Though they have rated doing exercise with the smart speaker is very interesting and engaging. Most of the criteria show an average of more than 4. The higher interest is mainly because the patients know the im-

portance of exercise at their age and they feel more engaged to do exercise while communicating with the smart speaker. Even the exercises are very simple and practical for the long term patients who face many issues in their daily life due to physical inabilities.

In the development phase training with the long term patients, they suggested playing music while doing exercises. The smart speaker is not developed to play parallel activities. Therefore it is not technically feasible. Considering that requirement it raises many other issues such as recognizing the voices of patients. If the patients do exercise while playing music they have to shout louder to move to the next step and the speaker could not get the voice of the patient. When considering the elderly patient care domain playing music while doing exercises is inappropriate. Since they could not speak louder to the speaker and they would love the calm environment also. Even in the evaluation patients did not suggest playing music. When considering the evaluation results the lowest mean can be seen in "It can be used to gain my mobility" which is 3.91. Compared to the responses in the exercise section. They believe gaining mobility is not possible by doing exercises while it is good for daily fitness.

Based on the final analysis we can identify the users have a very positive mindset on the exercise guidance. Since the instructions are very simple and short sentences it was quite easy to understand them. The user has to respond saying ok, done, yes or any other synonym to confirm the step is completed. Therefore we could identify more interest from the users to do exercise with the smart speaker.

In the developed proof of concept, our next evaluation is done on the small talk. Small talk is developed for long term patient care to build a conversation with the patients. From the interview process, researchers identified that elderly patients love to talk with someone. Even Though they feel more lonely because they do not have anyone to talk to for hours since everyone is very busy with their own lifestyle. As a solution, small talk is suggested in the research. The results show the long term patients show interest in using it as a conversation builder. The taking companion gets an average of around 3.5-4.09. The highest mean of 4.09 is for the quote"I felt like I'm talking to a friend". From the feedback for the talking companion, we can conclude that the elderly patients consider using the smart speaker as a friend. While they do not believe the smart speaker helps them to be independent. Elders believe when they are sad it is good that a smart speaker guides them to do meditation. Even while doing the meditation it is not appropriate to talk with the smart speaker. Therefore they suggested it is more appropriate if the speaker plays calm music and guides them throughout the meditation without expecting a response from them. From the evaluation, we identified when building the talking companion it should be more customized to the user to be effective. In view of the fact that all the patients do not have the same interest and personalities, when developing the small talk it should be more customized and based on the interests of users. For the evaluation purpose, we selected a general conversation.

Overall, we evaluated the use of the smart speaker and the opinion of the users on the device. Most of them had a positive opinion to use the device. When considering the mean of the rates. The lowest rate of 3.09 gained to the "As a patient, it is really a helpful technological device for me" They agreed it improves the life of a patient, nevertheless considering all the needs of the

patients it does not have much effect. The patients highly believe the device is very suitable when they feel lonely and help them to enjoy it. From the feedback, we can conclude that elderly patients love to embrace technology and are willing to try new things with the device. Even they believe that the smart speaker is a great companion for them. By using the device for a few hours they stated that they would like to recommend the device to the elderly patients. They agree the device is suitable for the long term patient care domain.

From the results of the final category, we can analyze the overall impression of the patients on the device. Compared to the research benchmark, we can identify a low average on the fact that the device helps their daily activities and them to be independent. Since their daily tasks are not integrated with the technology they do not accept the fact that the home mini can be used in daily activities. In most countries, people use different applications and they integrate those applications with the smart speaker to get the maximum outcome. In Sri Lanka since most of the elderly people are not familiar with the technology. They do not experience the benefits they can gain by technological devices. However, the results show the positive opinion of the patients on the solution.

After receiving the feedback from the patients, researchers rated the total satisfaction of the patients considering their response. We collected results from 11 patients. Their overall satisfaction range between 0.71 and 0.91. The satisfaction level of each user shows a positive rate since it is more than 0.7. When considering these categorically there are situations where it shows low satisfaction such as 0.63, 0.65, 0.66. For the exercises, there is a high satisfaction compared with other categories. From the 11 patients 2 patients are totally satisfied with the exercise function. In the analysis, we can identify patients satisfaction categorically as well as a whole. As a whole, the satisfaction of only one patient is less than 0.75. All the other patients have a satisfaction of 0.75 or greater than 0.75.

Finally, from the evaluation conducted on the use of smart speakers in the elderly patient care shows a positive impact on the users. The results prove that the smart speaker supports elderly patients to enjoy when they are lonely and to improve the quality of their life. Smart Speaker would be a great companion to talk, play games and do exercises. From the knowledge gathered researches prove the importance of the voice integrated personal assistance in the patient care domain to assist both the patient and the caretaker.

6.3 Conclusion

The dissertation is on developing a proof of concept to address the requirements of the long term patient care using the voice integrated personal assistance. This chapter provides an overall picture on the research we have conducted.

There were many researches conducted based on the voice integrated personal assistance, even though there were a limited number of researches focusing on the patient care domain. The research provides comprehensive knowledge on the elderly patient care domain focusing on the long term patients care taken by their families. The knowledge gained from the interview was very

significant to develop the solution and to attain the knowledge in the domain. Loneliness, lack of exercises, reminders, fall detection, emergency contact were a few main requirements identified in the interview. Basically. The proof of concept was developed based on the knowledge gained from the interviews and review analysis.

The review analysis shows how long term patients use the voice integrated personal assistant to assist their daily life. Mainly they use the device to listen to music, jokes, and news. A considerable amount of people use the device for home automation and other customized uses. In the review analysis, we identified different user segments and their distinct uses. The review analysis adds more value to the research since it shows a broader view of the use of voice integrated personal assistance.

Since we build the solution considering the requirements and the review analysis conducted in the patient care domain, in the evaluation it shows more validity. The sample patients were delighted by the features shown in the smart speaker. The smart speaker is a new hope in their monotonous life. Since most of the elderly people face difficulties due to the poor sight, using a smart speaker is more effective than using mobile phones. When integrating other applications with the smart speaker the patients can get an outstanding experience which improves their lifestyle.

In conclusion, considering the results of the research, we can state that the voice integrated personal assistance helps the long term patients to be more independent and enjoy their lonely time more joyfully. Elders would embrace the technology as a companion to build conversations and to play games. The device can be used to do more engaging exercises. However, the device could not replace the caretaker since it is a more emotional and caring task. While the voice integrated personal assistance can be used to assist both the caretaker and patient to build more close connections and to make life easy.

6.4 Future Works

Within the research scope, the proof of concept is developed in order to get feedback from the user. Since the participatory design is used for the development we can alter the requirements based on user feedback. The developed proof of concept can be developed further. Then the effective user feedback can be collected. The effectiveness of the results can be increased by further development. Finally deployment and evaluating the system on different users may improve the results. Since there are many other requirements identified the system can be further developed, integrate other devices and applications according to the user expectations.

The requirement gathering is conducted basically on the long term patients at home. Hence, there would be different requirements for patients in care homes and hospitals. The architecture can be improved to address their requirements. This is another area that can be touched by the solution.

The research can be further continued to identify the feelings of the long term patient based on their tone of voice, words they use. Based on those factors the system can decide the mood of the user and depend on it can decide the conversation flow. This would lead to building a more engag-

ing conversation which is more effective for the user. By training with the user, the architecture could be more customized to the interests of users. Moreover, the user feels more comfortable to build conversation with the smart speaker. Even the smart speaker trained to understand the ways the user talks.

When developing the architecture to Sri Lankan context one of the main issues was the language barrier. To overcome it the architecture can be developed for the Sinhala language. Since there is a considerable number of patients who love to communicate with the smart speaker in Sinhala, developing the architecture to respond in the Sinhala language is another research area to look into.

Within the research scope, we covered the elderly patient care requirements. Since we identified many different categories in the patient care domain, in future research we can extend the research to other user groups in the domain area. While we conducted the research we were able to identify the importance and the interest to use the technology to other user categories. Therefore this research opens the doors to another research area of the young patient category who is more familiar and interested in using technology. The war victims, long term patients with viral diseases and other patient categories can be considered to extend the research.

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Appendices

Appendix A

Interview Questions

University of Colombo School of Computing

Sri Lanka

(Prepared for final year research in Degree of Bachelor of Science Honours in Information Systems)

The Use of Conversational Interfaces in Long Term Patient Care

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Interview questions for Caretaker

- Number:
- Age:
- Disability of the related patient (if any):
- The living environment of the patient (Home/ Nursing home/ Elderly home/Hospital):

1. How long have you taken care of the patient?
2. Is there any disability in the patient?
3. Are there any difficulties the patient faces in communication?
4. What are the issues you faced when taking care of such a patient?
5. Do you have any suggestions to overcome such issues?
6. How do you Handle a Crisis or Medical Emergency?
7. How many and which hours does the patient get your care during a normal working day?
8. How does the care happen on the days that you are not working?
9. How do you keep the records of diet control charts, medication time charts etc about the patients you care for?
10. Does the patient prefer to be alone and independent?
11. What kind of daily activities relating to entertainment does the patient have?
12. If the patient talks with someone are there any usual topics or interested areas?

13. How does the patient recall his/her favourite memories/life events?

14. How does the patient inform you if any kind of non-standard care is required?

15. What is your experience with handling patients using communication media such as phones and computers?

16. How does the daily activity routine of the patient flow?

*Note: Additional follow-up questions will be asking, as appropriate, with each participant.

University of Colombo School of Computing

Sri Lanka

(Prepared for final year research in Degree of Bachelor of Science Honours in Information Systems)

The Use of Conversational Interfaces in Long Term Patient Care

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Interview questions for Patient

- Number:
- Age:
- Disability of the related patient (if any):
- The living environment of the patient (Home/ Nursing home/ Elderly home/Hospital):

1. What are your daily routine activities?
2. Are there any difficulties when engaging in them?
3. Do you have a caregiver?
4. Do you prefer having a caregiver?
5. Do you prefer to be independent or have someone with you always?
6. How do you remind yourself about taking medicine?
7. Whom do you prefer to call when you need some assistance to do your day to day activities?
8. Do you call your relatives? To whom? Frequency?
9. What are the communication difficulties you face?
10. What do you like to do when you are alone?
11. How do you feel about being in one place?
12. What do you want to do when you are in bed?
13. What are the issues you face when communicating?

14. Are you interested in using smartphones?
15. Do you use a smartphone? How often?
16. Do you have any difficulties using phones?
17. How comfortable are you with technological devices? Can you rate it 1-5?
18. How comfortable are you with technological devices in the
19. English language? Can you rate it 1-5?
20. Do you have any experience with Personal Intelligent Assistant technologies or conversational interfaces?
21. What kinds of radio/television programs do you prefer to watch daily?

    *Note: Additional follow-up questions will be asking, as appropriate, with each participant.

Appendix B

Evaluation Questionnaire

University of Colombo School of Computing

Sri Lanka

(Prepared for final year research in Degree of Bachelor of Science Honours in Information Systems)

The Use of Conversational Interfaces in Long Term Patient Care

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Questionnaire for evaluation

1. General Information:

a	**Gender**	
b	**Age**	
c	**Diseases/ illnesses**	
d	**Disabilities**	

2. Mobility level (X):

I am a bedridden person. I rarely walk	
I am not very active, but I can walk or manage to do some work with someone's help	
I'm quite active, but often I'm in one place	
I am a somewhat active person. I can manage to do some work	
Even though I have an illness. I am an active person	

3. Level of English Literacy (X):

Very Poor		Poor		Medium		Good		Very Good	

4. Level of Technology Literacy (X):

Very Poor		Poor		Medium		Good		Very Good	

5. Google Home Device

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a	Wake up the device is easy					
b	Selecting a feature is easy					
c	Sound is clear					
d	Language is understandable					
e	Talking to the device rather than typing or pressing buttons is helpful/good/easy					
f	I like to keep a device like this with me					
g	I can use such a device as a caretaker					

6. Mind Games

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a	I enjoy the game					
b	Game is helpful when I feel lonely					
c	Game identify my answers correctly					
d	I understand the questions					
e	Game is useful to me					
f	I feel engaging in the game					
g	Do you often feel like playing the game					

h. Suggestions to improve the game?

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.....

.....

i. When do you feel like playing this game?

.....

.....

.....

7. Bedridden Exercises

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a	Easy to wake up the feature					
b	Instructions are clear					
c	It identifies my responses clearly					
d	I enjoy engaging in daily fitness					
e	It is a great help for doing exercises					
f	It can be used to gain my mobility					
g	I like to have this feature					

h. What are the difficulties you had while engaging in this feature?

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.....

.....

i. Suggestions to improve the feature?

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8. Talking companion (Customized small talk)

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a	I think this will help me when I'm bored and lonely					
b	I feel this helps me to fresh my mind					
c	I felt like I was talking to a friend					
d	I think this will make me more independent					

f. Suggestions?

.....

.....

.....

9. Conclusion

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a	It helps to enjoy my life, even though I'm a patient					
b	It is good to pass the time					
c	It's good for my loneliness					
d	It is a great help for my daily activities					
e	I feel independent when using					
f	It is like a companion					
g	As a patient, It is really a helpful technological device for me					
h	I like to have this device with me					
i	I recommend this device to a person like me					

10. Overall feedback questions

a. How do you feel about using this device as a daily part of your life?

.....

.....

.....

b. Any suggestions to improve?

.....

.....

.....

c. Any other feedback?

.....

.....

.....

Appendix C

Sample codes used for the development

```
'use strict';

const {dialogflow,Suggestions,Image,} = require('actions-on-google');
const functions = require('firebase-functions');
const app = dialogflow({debug: true});

// Handle the Dialogflow intent named 'Default Welcome Intent'.
app.intent('Default Welcome Intent', (conv) => {
    conv.ask(`Welcome! I'm really happy to talk to you again. `);
    conv.ask(`How are you feeling right now?`);
});

app.intent('actions_intent_NO_INPUT', (conv) => {
  // Use the number of reprompts to vary response
  const Count = parseInt(conv.arguments.get('REPROMPT_COUNT'));
  if (Count === 0) {
    conv.ask('Welcome friend!');
    conv.ask('Hope you are doing fine. How are you feeling right now?');
  } else if (Count === 1) {
    conv.ask(`How are you feeling friend?`);
  } else if (conv.arguments.get('IS_FINAL_REPROMPT')) {
    conv.close(`Sorry we're having trouble. Let's ` +
      `try this again later. Goodbye.`);
}
});

app.intent('sad', (conv, {sad}) => {

    conv.ask(`<speak> Friend, Don’t worry. I’m always here with you. </speak>`);
    conv.ask(`<speak rate="slow"> Let’s do some meditation to feel better.</speak>`);
    conv.ask(`Shall we?</speak>`);
    conv.ask(new Suggestions('Yes', 'No'));

});

app.intent('happy', (conv, {happy}) => {

    conv.ask(`<speak> Let’s make the day way better. </speak>`);
    conv.ask(`<speak rate="slow"> Let’s hear a joke. What do you say?</speak>`);
    conv.ask(`Shall we?</speak>`);
    conv.ask(new Suggestions('Yes', 'No'));

});

exports.dialogflowFirebaseFulfillment = functions.https.onRequest(app);
```

Figure C.1: code sample for companion conversation voice agent

Figure C.2: code sample for companion conversation voice agent