Health Empowerment (HE) through Conversational Agents (CAs)

A Mapping between CA Architectural Components and HE Elements to Design CA Interventions

A thesis submitted in fulfilment of the requirements for the award of a Research Master's

Maryam Nawaz

Supervised by: Dr Marco Alfano (IVI), Prof. Markus Helfert (IVI), &

Prof. Joseph Timoney (Computer Science Department)

Maynooth University, Ireland

Department of Computer Science

May 2026

Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Masters in Research is entirely my own work, that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Student Name: ..Maryam Nawaz............ Student ID: ..23250004..................

Signature: ...Maryam Nawaz................ Date: ......June, 2026.............

Acknowledgments

Firstly, I would like to thank my supervisory team, Dr. Marco Alfano, Professor Markus Helfert and Professor Joseph Timoney for their continuous guidance, invaluable support, patient assistance and commitment to this project. I truly appreciate the funding supported by the Science Foundation Ireland (SFI) grant *13/RC/2094_P2 and co-funded under the European Regional Development Fund through the Southern & Eastern Regional Operational Program to Lero - the Science Foundation Ireland Research Centre for Software (www.lero.ie)*.

I wish to thank my Design Science discussion group and the Business Informatics Group (BIG) at Innovation Value Institute, Sana Kiran, Simon Hanratty, Dr Mansoor Ahmed and Peter Jean Paul. Furthermore, I am very grateful to all the participants at each stage of this project for the time and effort that they have committed to this project. Their participation and feedback are extremely significant and beneficial.

I also want to thank my family for their encouragement and patience throughout these years. I would like to express my gratitude to my parents and siblings, who made it all possible for me and supported my education throughout my life. Finally, I will remember this journey at MU not just for the knowledge gained, but for the quiet moments in between, the times I felt alone in a new country, the uncertainty of finding my way, and the stubborn hope that carried me through. This degree represents more than academic achievement; it's the proof that every difficult step was worth taking, and that feeling lost sometimes leads to exactly where you're meant to be.

Publication

Conference:

Nawaz, Maryam; Helfert, Markus; Timoney, Joseph; Alfano, Marco (2024): Empowering Patients Through Conversational Agents Enhancing Participation and Personalization in Healthcare. Mensch und Computer 2024 - Workshopband. DOI: 10.18420/muc2024-mci-ws03-154. Gesellschaft für Informatik e.V.. MCI-WS03: 2nd International Workshop on Co-Creation of Hybrid Interactive Systems for Healthcare. Karlsruhe. 1.-4. September 2024

Contents

List of Abbreviations

Abbreviation	Full Text
HE	Health Empowerment
CA	Conversational Agent
AI	Artificial Intelligence
WHO	World Health Organization
HEE	Health Empowerment Elements
HCA	Health Conversational Agents
MRQ	Main Research Question
SRQ	Sub Research Question
DSRM	Design Science Research Methodology
LR	Literature Review
SLR	Systematic Literature Review
CLR	Critical Literature Review
NLP	Natural Language Processing
NLG	Natural Language Generation
DSS	Decision Support System
DUM	Dynamic User Model
DB	Database
SDT	Self-Determination Theory
TAM	Technology Acceptance Model
BCT	Behavioural Change Theory

List of Tables

List of Figures

Abstract

Health Empowerment (HE) Through Conversational Agents (CAs)

A mapping between CA Architectural Components and HE elements

Maryam Nawaz

The digital transformation of healthcare, marked by Conversational Agents (CAs), promises to enhance patient engagement and self-management. While these technologies have grown in capability, limited research systematically connects their architectural design to foundational principles of user empowerment. This disconnects results in CAs that often function as transactional tools rather than transformative partners, failing to reliably foster the user autonomy, competence, and relatedness necessary for sustained health behaviour change.

This research addresses this critical gap by investigating how the technical architecture of Health CAs can be deliberately designed to implement health empowerment. Adopting a Design Science Research (DSR) methodology, this research proposes a novel theoretical framework. The development process involved a comprehensive literature review to establish core Health Empowerment Elements (HEEs) and a systematic taxonomy of CA architectural components. Through iterative design and validation via expert reviews, a mapping between these components and the HEEs was established with a design prototype to create a functional blueprint.

The primary artefact of this thesis is the Health CA Empowerment Mapping Framework. This research solution provides designers and developers with a structured model to architect systems where components like the Dynamic User Model and Explanation Engine, with an empowerment-specific components layer, are explicitly engineered to support specific health needs with evaluated prototype design. The framework offers an actionable blueprint for creating HCAs that are not only technically sound but also psychologically grounded.

This thesis demonstrates that a purposeful, component-level mapping to empowerment theory is essential for creating HCAs that can effectively and measurably empower users. The study contributes a valuable tool for both research and practice, outlining a clear path for developing digital health interventions that truly support user-centric health empowerment.

Chapter 1: Introduction

This chapter presents the background of the proposed research, beginning with an introduction to **health empowerment (HE)** and **conversational agents (CAs)**, emphasizing their growing significance in healthcare delivery and individual well-being. It establishes foundational definitions of health empowerment, its core elements, and the CAs system architectures. Subsequently, the major issues, research questions, and objectives are identified and explained. Additionally, an overview and a breakdown of the thesis structure are provided in the final section.

1.1 Research Background

This section discusses the health empowerment elements concepts with a focus on conversational agents (CAs). Finally, the concepts of health empowerment elements and CA architectural components are discussed as two interdisciplinary concepts that lead to the proposition of a solution framework for this research.

1.1.1 Health Empowerment

The 21st century has ushered in a paradigm shift in healthcare, redefining the patient's role, moving from a passive recipient of care to an active participant. Individuals now engage with their health through continuous personal insights and self-management tools (Mesko et al., 2025). This transition is central to the concept of health empowerment, which the World Bank (2002) defines as the process of enhancing an individual's capacity to make informed choices and translate them into desired actions and outcomes (as cited in Mesko et al., 2025). In a healthcare context, empowerment represents a transformative process (Kapeller et al., 2023) that enables individuals to gain greater control over their health decisions, effectively manage their conditions, and reduce dependency on healthcare providers (European Patient Forum, 2021; WHO, 2024).

Health empowerment (HE) is a comprehensive process that integrates multiple elements, including: (1) providing health knowledge and education (Linders et al., 2022; Jusoh et al., 2023), (2) getting personalized recommendations for decision-making (Muhammad et al., 2024), (3) enabling health self-management (EI Kamali et al., 2020), and (4) continuous motivational support (Montagna et al., 2023). Together, these elements create a complete empowerment cycle. The digitalization of healthcare has been a critical catalyst for this empowerment. Previously confined to the boundaries of patient-doctor interactions during clinical visits, empowerment is now facilitated by a wide array of health technologies (Mesko et al., 2025). Individuals have unprecedented, round-the-clock access to medical information, online screening tools, remote consultation services, and self-management platforms, enabling continuous and proactive engagement with their health across all well-being domains.

1.1.2 Conversational Agents in Healthcare and Their Architecture

Modern chatbot systems and conversational agents (CAs) represent another advancement in terms of human-like conversation (SmythOS, 2024). These systems provide symptom checks, personalized advice, and health management support. The key difference between chatbots and CAs lies in their capabilities. Chatbots set simple rules for common questions (SmythOS, 2024). CAs, however, use advanced AI for complex conversations, learning from interactions to provide tailored advice. As digital health grows, CAs emerge as ideal tools for health empowerment, helping patients to understand health factors, make informed decisions, and maintain positive behaviours (Kurniawan et al., 2024; Gobel et al., 2024).

The introduction of Apple's Siri (2011), Google Now (2012), and Amazon's Alexa (2014) with defined architectures brought conversational interfaces to mainstream consumers, paving the way for healthcare applications. Prior studies have explained general system architectural components in health CAs, including:

- User interfaces for queries : (N & J et al., 2023 ; Jusoh et al., 2023 ; Muhammad et al., 2024)
- Natural language processing (NLP) with classifiers: Interprets user inputs, extracts meaning, and understands context (Muhammad et al., 2024; Bandopadhyay et al., 2023)
- Dialog management/Advisory/
- Conversation manager/Dialog management unit/Workflow engine/Information manager/Conversation protocol: Manages the conversation flow, using NLP to maintain context in interactions (N & J et al., 2023; Färber et al., 2023)
- Decision support system/recommendation engine/adherence agent/advisory manager: Applies NLP to interpret user queries and provide appropriate health recommendations (Montagna et al 2023, Linders et al 2022, Färber et al 2023)
- Chatbot API/External user interface integrations/REST APIs/API from partners/API: Facilitates interactions between the CA and other systems, such as services and other user interfaces, databases (Montagna et al 2023, Lagakis et al 2023, Maia et al 2023, Khadija et al 2021)
- Action execution/Action selection/Service chatbot/actions: Executes specific actions based on user inputs and system decisions, such as updating goals or sending alerts (N & J et al 2023, Hermawan et al 2022, Abdulrahman & Richards 2019)
- Dynamic user model/User model/health literacy agent: Continuously update and refine user profiles to enhance personalization (Angelini et al 2022, Abdulrahman & Richards 2019, Färber et al 2023)
- Rule engine/Logical rule/Bot logic/Business logic/Conversational coach engine: Apply predefined medical guidelines and business rules based on user input (Kamali et al, 2020, Katariya et al 2019, Preininger et al 2020)
- Knowledge base for query answering: Access and compare user requests and retrieve medical information (Jusoh et al., 2023; Hermawan et al., 2022; Maia et al., 2023; Khadija et al., 2021)

- Explanation engine/Education manager: Provides detailed explanations, justifications, and clarifications for the information given by CA (Abdulrahman & Richards 2019, Färber et al 2023)
- Cloud/Service, DBs/Service, Provider/Message, DB/Dataset/DB/Storage: Provide a centralized repository of medical information, such as symptoms, treatments, medications, and storage (Montagna et al 2023, Muhammad et al 2024, Maia et al 2023, Thomas et al 2023)
- Sensor's data connectivity: Data from wearable sensors and medical devices for personalized recommendations and updating progress on health goals (Sureshkumar et al 2022, Montagna et al 2023, Färber et al 2023)
- Natural language generation for query responses (Montagna et al., 2023, Jusoh et al., 2023, N & J et., al 2023)

Newer conversational agents are more dynamic and personal than the older, static systems. They go beyond simply exchanging information and can positively influence how users act and the results they achieve. These AI-driven systems empower users to take more active roles in their care while addressing common challenges like information accessibility, health management, and personalized guidance (Yang et al., 2022).

1.2 Motivation

The 21st century has witnessed a paradigm shift in healthcare toward digital health, transforming patients into active participants who manage their health through data, information, and digital tools (Mesko et al., 2025). This transformation is fundamentally rooted in the concept of **health empowerment**. This empowerment process encompasses the core domains of holistic well-being, for example, physical/physiological, nutritional, cognitive/mental, and social health, each essential for comprehensive health management (Angelini et al., 2022).

The digitalization of healthcare has been catalysed by technologies that make information, online screening, and consulting services readily accessible. Among these technologies, conversational agents have emerged as particularly promising tools for health empowerment (Kurniawan et al., 2024; Johannes et al., 2024). Unlike simple chatbots, which have followed basic rules (SmythOS, 2024), advanced CAs use sophisticated AI for complex conversations, learning from interactions to provide tailored advice and support across various health domains, including symptom checking, medication management, and mental health support (Hossain et al., 2020; Kurniawan et al., 2024; SmythOS, 2024).

Prior frameworks have successfully linked isolated components to singular empowerment aspects (see Figure 1.1); for instance, knowledge bases have been shown to support information delivery (Linders et al., 2022), and sentiment analysers have been correlated with providing emotional support (Montagna et al., 2023). However, empowerment is a multidimensional construct, encompassing not just knowledge and emotion but also self-management capabilities, motivation, and informed decision-making (Sureshkumar et al., 2022). Current architectures lack a comprehensive model that demonstrates how a coordinated set of technical components can jointly address this full spectrum of health needs.

This component-level incoherence has direct practical consequences. The absence of a unified framework means developers lack evidence-based guidelines for designing systems where components work synergistically. Consequently, development often defaults to a trial-and-error approach that prioritizes isolated functionalities over a coherent strategy for fostering user autonomy and growth. This results in CAs that may perform specific tasks but fail to adapt to and support the user's evolving health journey holistically (Sanjeewa et al., 2024). Therefore, this research is motivated by the critical need to move beyond partial solutions. It addresses the gap between the multidimensional theory of health empowerment and the uncoordinated implementation of CA architectures by proposing a structured framework.

1.3 Problem Statement

When examining health empowerment in digital health, particularly through conversational agents (CAs), multiple critical aspects must be considered. Research on health empowerment through conversational agents (CAs) encompasses two critical dimensions: (1) the implementation of core health empowerment concepts, and (2) the corresponding CA design (system architecture components). The primary problem noted is that no methodology properly integrates health empowerment elements with CA architectural components through a framework for guidelines to design a truly empowered CA.

The following Figure 1.1 illustrates the research problem: to develop a framework that explicitly connects CA architectural components to health empowerment elements. This involves identifying which components (e.g., dynamic user models) best support which empowerment elements (e.g., personalized health management, motivational support), determining how these components should interact, and establishing appropriate evaluation metrics.

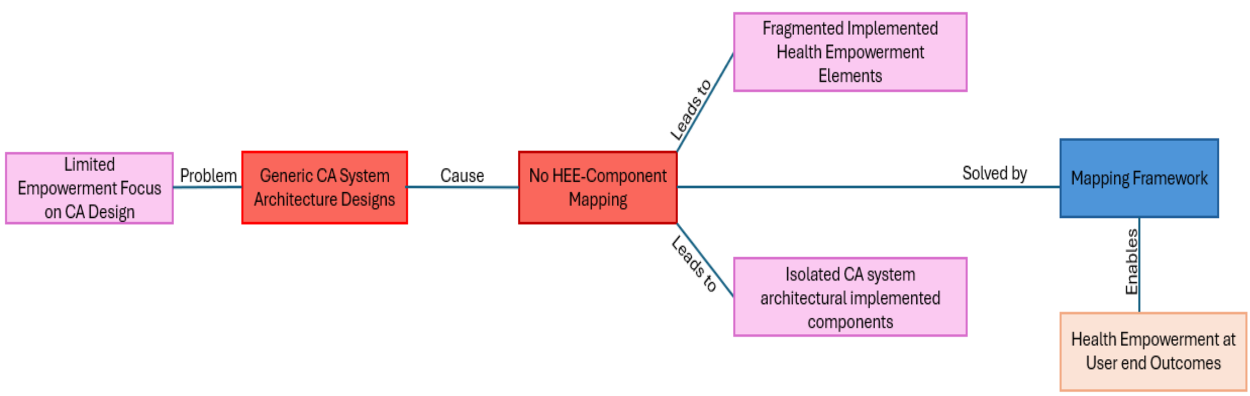


Figure 1.1: Problem Statement

1.4 Research Objectives

The main objectives of this research are as follows:

- First, this research establishes a methodology for analysing and standardizing health empowerment elements (HEEs) that currently appear under disparate terminologies across literature. By synthesizing these conceptually similar but variably labelled components, the research creates a unified taxonomy of empowerment dimensions essential for CA design.
- The second objective involves constructing a novel mapping framework that explicitly links these standardized HEEs to specific architectural components of health CAs and proposed a prototype based on the framework. This framework will bridge the current gap between empowerment theory and technical implementation, enabling the creation of CA systems that comprehensively address all critical dimensions of health empowerment through their architectural design.

1.5 Research Questions

To address the research problem and achieve the objectives, a main research question with two sub-research questions is proposed below.

Main Research Questions (MRQ): How can the architectural components of health conversational agents (CAs) be systematically mapped to specific elements of health empowerment to optimize their design for improved health?

By systematically investigating these Sub Research Questions (SRQs 1,2), the research provides a comprehensive solution. Each question targets a distinct aspect of health empowerment in conversational agents (CAs).

The SRQ 1 examines health empowerment elements (HEEs), including their taxonomies, terminologies, and integration within conversational agents (CAs). Since existing literature presents numerous HEEs with varying definitions, this research will analyse and generalize these elements to identify conceptual similarities. Chapter 2 details the methodology for standardizing differently labelled but functionally equivalent HEEs for inclusion in this study. The SRQ 2 investigates the systematic mapping between standardized HEEs and CA architectural components. This analysis establishes how technical implementations can support specific empowerment outcomes.

Sub-research question (SRQ 1): What are the existing health empowerment elements in current implementations and their relationship with health CAs?

- Identifying relevant studies that discuss HEEs in the context of conversational agents (CAs);
- Systematically categorizing HEEs across varying taxonomies and terminologies.

The SRQ 1 aims to verify which HEEs have been implemented in existing CA systems and determine common patterns in their application. To achieve this, the research analyses and groups HEEs with similar definitions, consolidating overlapping terminologies into a unified framework. In Chapter 2, Figure 2.2 illustrates the methodology for deriving these HEE groupings, based on prior research studies. The figure outlines key HEEs, their descriptions as foundational building blocks, and their potential implementation through CAs. Furthermore, the next step has been proposed in terms of a mapping framework where the CA architectural components and HEEs have been mapped (see Fig. 4.2).

Sub-research question (SRQ 2):

- What are the CA architectural components that have been implemented so far to support health empowerment at the user's end.
- How to map HEEs to CA architectural components to design a health empowerment CA.

1.6 Contributions

This research develops a mapping framework that connects conversational agent (CA) architectural components with standardized health empowerment elements (HEEs). The framework identifies which CA components specifically support empowerment elements. The contributions are organized and listed into academic and industrial impacts.

Academic Contributions:

- Introduces methodology for identifying and classifying major HEEs found in health CA research. The HEEs were identified through an exploratory analysis of health CA literature. This involved an initial exploratory review to capture relevant concepts, followed by a thematic synthesis of peer-reviewed studies to group and refine these concepts into a coherent taxonomy. (See Fig 2.2 in Chapter 2).
- Presents a structured framework for developing CAs that effectively incorporate health empowerment features (See Figure 4.4 in Chapter 4).
- Presents a prototype design based on the structured framework (Prototype section 4.6)
- Highlight metrics and theories to assess how well CA architectures support empowerment through HEE integration.

Industrial Contributions:

- Provides a research-based guide showing how specific CA components relate to empowerment outcomes.
- Offers practical guidelines in terms of a mapping framework for building CAs that genuinely enhance user empowerment in healthcare contexts.

- Provides a prototype based on the proposed framework to implement health empowerment focused CAs.

1.7 Thesis Structure

This research is guided by design science research methodology (DSRM), combined with the concepts and techniques. Hence, the chapters of the thesis are organized according to the main concepts and process of design science. The remaining contents of the thesis are structured as follows:

Chapter 2 describes literature reviews in relation to health empowerment (HE), HEEs, conversational agents (CAs), and CAs' architectural components and how they work, methods adopted for mapping framework, illustrating the detailed background of the progress made in this domain. It provides an in-depth analysis of different aspects to explain the current state of the art and problems faced in HE and their relationship with CAs and their architectural components. Chapter 2 also introduces different concepts, theories, techniques, and research methodologies that are beneficial to systematically conduct this research and then explains how to select some of them and adapt them to this research. Chapter 3 outlined the research methodology, with a specific focus on the application of DSRM to this research.

Subsequently, in Chapter 4, the health empowerment CA architectural components mapping framework is designed and developed based on the results generated by Chapters 2 & 3. This chapter answers the SRQ2 concerning how to map CA architectural components to respective HEEs into a framework, along with several evaluation theories and measurements for the proposed framework. Chapter 4 also includes the detailed evaluation process in terms of experts' surveys and results. After this evaluation with experts, this thesis presents IOS version of prototype design, which can be used as referenced design in future to implement health empowerment focused CAs. Chapter 5 concludes this research and makes contributions to prove that this research achieves the objectives and answers the MRQ. It analyses the challenges of this research with focused objectives and provides an outlook on future research. To present an overview of this research, the following table demonstrates the focus, the methods applied, along the results gained in each chapter associated with the MRQ and SRQs.

Table 1.1: Overview of this research

Chapter	MRQ or SRQs	Content	Output
1	-	• Brief introduction of HE, HEEs, and CAs, motivation, • Problem statement, research objectives and contributions	Objectives and research questions
2	SRQ1, SQR2	• Importance of research, and selected literature review	HE, HEEs and CAs in healthcare, HEE elements, summaries, and

		method for this research related work, • Literature analysis of HE, HEEs, CAs, and their architecture and components, • Literature findings and theoretical foundations to design the proposed mapping framework	definitions, and architectural analysis from previous research studies
3	-	• Research application based on DSRM	The DSRM is chosen to underpin this research
4	SRQ2	• Design and development of proposed artefact (CA architectural components and HEEs mapping framework), evaluation though experts' interviews and surveys	• A framework with systematic process to design health empowerment related CAs • A prototype design of health empowerment focused CAs and it's evaluation
5	MRQ	• Discussing contributions made by this research, limitations and future directions of this research	Contributions, limitations and future work

The next chapter 2 will present a comprehensive literature review to establish the theoretical foundation and current state of research supporting this proposed framework.

Chapter 2: Literature Review

The literature review in Chapter 2 examines the core fundamental theories and research methodologies necessary to create a complete background analysis from which an appropriate methodology can be derived to address the research questions and proposed health empowerment mapping framework.

2.1 Importance of the Research

Research methodologies provide the foundational frameworks for systematic inquiry across diverse fields. The selection of an appropriate methodology is paramount, as it directly shapes the research questions, data collection, and the type of knowledge claims a study can produce (Patel and Patel, 2019). This is particularly critical in interdisciplinary domains like digital health, where quantitative, qualitative, and design science approaches each technological contribute distinct insights into the efficacy and user experience of interventions (Vallejo et al., 2020).

Rogers (2004) defines research as crucial because it systematically answers questions, builds knowledge, and enhances practice. Carter defined the importance of research as established through value arguments that highlight its significance, address research gaps, and justify the relevance of findings, ultimately enhancing the understanding of critical issues and contributing to advancements in various scientific fields (Carter 2016).

2.2 Research Methodology Selection for Guiding this Research

The preceding section summarized various research methodologies and their characteristics (see Table 2.1) based on selected studies from the literature. From these, **Design Science Research Methodology** was selected as the primary guiding framework for this thesis. This selection is justified by the fundamental nature of the research problem, which requires the creation of a novel solution to an identified and significant class of problems, a core tenet of Design Science (Hevner et al., 2004; Peffers et al., 2007).

While DSRM provides the overarching structure for artifact development, this research adopts a stance of methodological pluralism to ensure scholarly rigor. The DSRM paradigm does not prescribe a single method for all research activities but encourages the integration of complementary techniques to strengthen the design process (Hevner, 2007). Consequently, methods from other research traditions are incorporated at specific stages: a systematic literature review grounds the problem identification and component discovery in existing evidence, and conceptual analysis is employed to define and structure the taxonomy of CA components.

Table 2.1: Research Methodology Discussion

Research Methodology	Purpose	Application in This Research

Design Science (Selected as the primary methodology)	Real-world problem-solving methodology and generating knowledge, and creating artefacts	Main research methodology to guide this research
Qualitative Research . (Esiere et al., 2014; Al Kilani & Kobziev, 2016).	Explanations to explore a particular phenomenon generally work with the study of human behavior	Used for critical analysis of empowerment implementation gaps in current health CA solutions
Action Research (Sharma, 2022; Pracht, Toelle and Broaddus, 2022).	Facilitate immediate and practical solutions to problems within educational and organizational contexts. It emphasizes participatory inquiry, allowing individuals to reflect on their practices and implement changes that enhance learning and social situations.	Using its principles to analyze current situations and issues from academia and industry perspectives
Grounded Theory (Chapman et al., 2015).	Applying qualitative research to generate new theories based on observed phenomena and systematic data analysis.	Some previous feature measurements are used

2.3 Methods for Literature Review

As this research requires relevant information and data-supported analysis, literature reviews (LRs) are valuable approaches for understanding current trends and collecting domain-specific data to address the research questions. Literature review methodologies encompass various approaches designed to synthesize existing research effectively. These methodologies can be categorized based on their objectives, strengths, and limitations factors which are essential for researchers to consider when selecting an appropriate method (Chukwuere, 2023). Every research project, whether qualitative or quantitative, begins with a review of relevant literature, a common foundational step shared across methodological approaches (Višić, 2022). To better understand literature review methods, several LR approaches based on selected studies are discussed and summarized in Table 2.2.

Table 2.2: Literature Review Methods

LR Method	Description	Relevance to this Research
Exploratory LR Phase 1	Serves as a foundational tool for synthesizing existing research on a specific topic, identifying gaps, and suggesting future directions	Used to find the HEEs, background of CAs in healthcare

		To explore the foundations of research methods, theories, and DSRM
Systematic LR Phase 2	It has clear requirements for the search strategy and selection of scientific publications, which are called inclusion (time - period, country, research objectives, social conditions, etc.) and exclusion criteria as well	Used to identify the CA architectural components and implemented health empowerment elements in included SLR studies
Scoping Review	The objective of a scoping review is to explore and comprehend the extent and comprehensiveness of the existing literature regarding a specific subject.	Used to explore existing literature on CAs in healthcare, research methodologies, and DSRM

2.4 Literature Review Methods for this Research

As established earlier, this research requires a method to systematically identify health empowerment elements (HEEs) and examine their relationship with conversational agents (CAs) and CA architectures. The study employs a two-phase review process: To perform SLR, the following criteria and number of included studies have been considered, as mentioned below in the Figure 2.1.

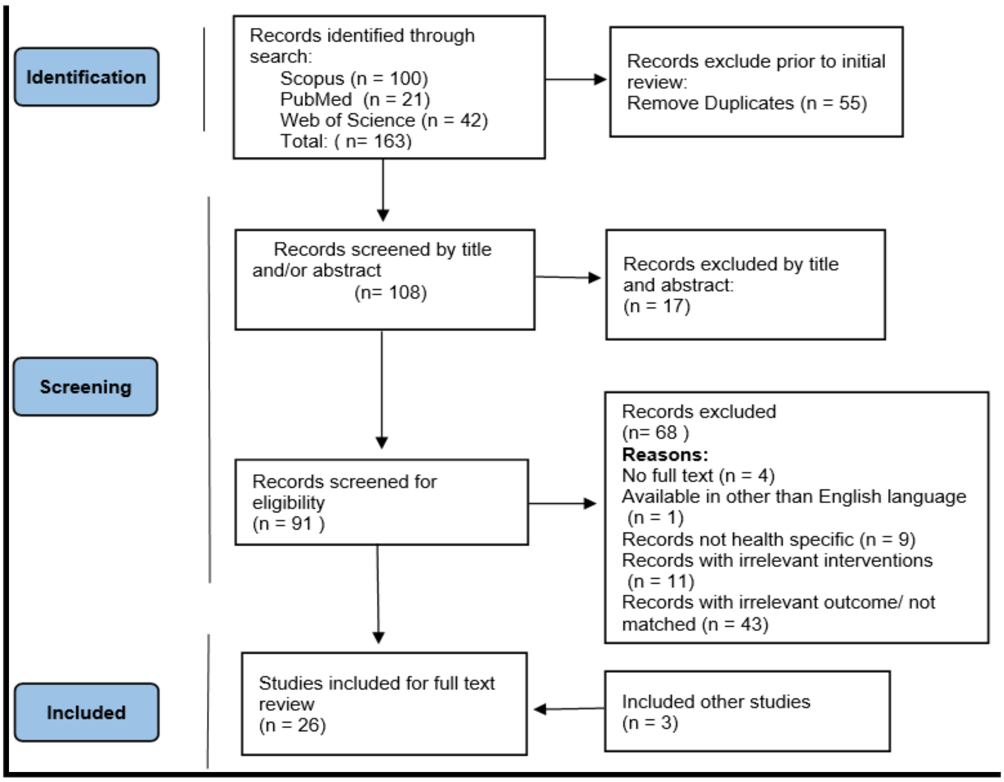


Figure 2.1: Systematic Literature Review (PRIZMA Technique)

2.5 Health Empowerment (HE)

As stated in chapter 1, HE is a process that involves giving people the tools they need to take control of their health, express interest in and involvement with it, and do it in traditional or digital methods. These elements are highlighted in various studies over the past five years that emphasize key aspects essential for empowering individuals to achieve positive health outcomes through traditional and technology-mediated healthcare interactions. Below (see Figure 2.2) is a refined synthesis, based on frequent mentions, commonalities, and conceptual alignment within the literature. The methodology employed to derive these elements involves identifying frequently discussed themes, clustering similar elements with varying terminologies, and aligning them with core concepts of health empowerment.

In this research, these important elements have been categorized into four major elements for convenience and reviewed from the literature. The figure shows the literature findings in terms of input as fragmented and HEEs with different terminologies. The synthesis method has been used in this research to group the similar, commonalities, and frequently used HEEs as described in Figure 2.2

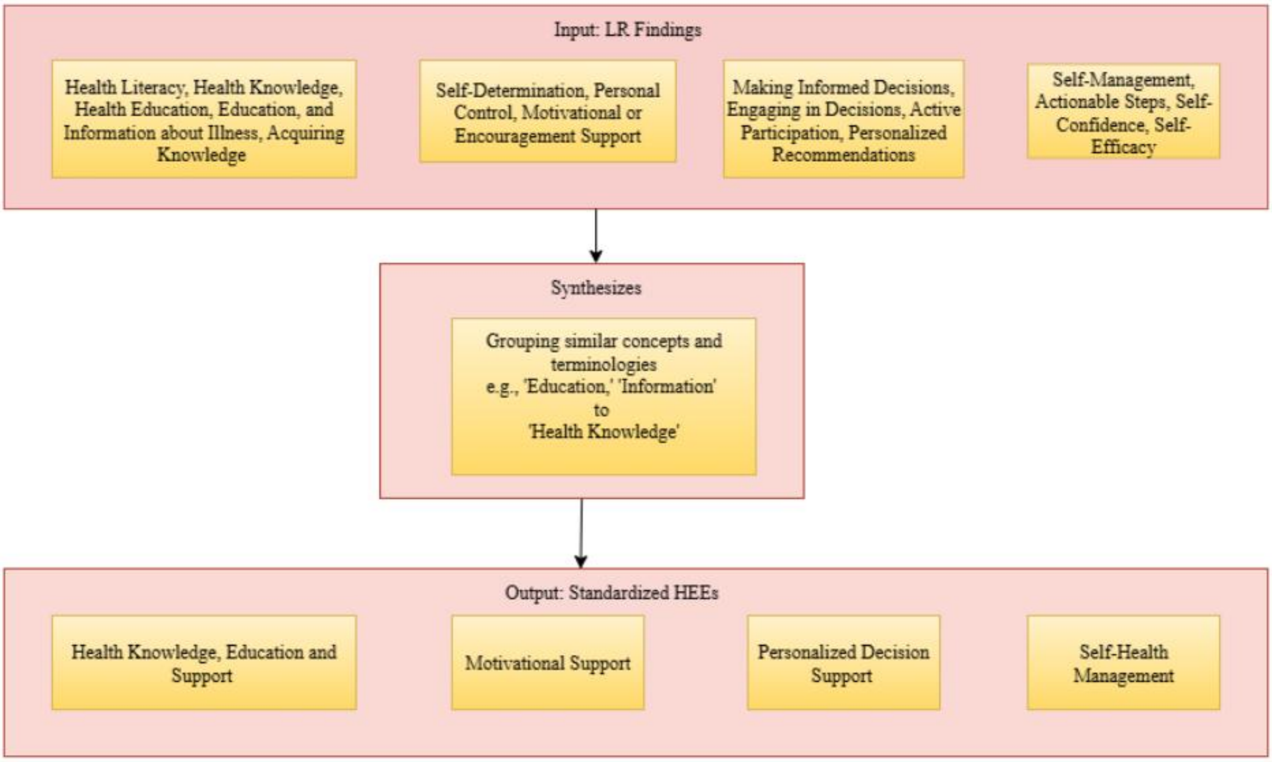


Figure 2.2: Standardisation of HEEs for the mapping framework

2.6 Health Conversational Agent (HCA)

Conversational agents (CA), i.e., software applications that serve as interfaces between human users and information and communication systems by processing natural language, have been gaining importance for years (Johannes et al., 2024). ELIZA, as a chatbot, was the first conversational interface that was implemented for psychotherapists. With E.L.I.Z.A. in 1966, Weizenbaum made the first moves toward a text interface between humans and information systems (IS). A text input-generating IS called E.L.I.Z.A. mimics a psychotherapist during a therapy session (Heuer et al., 2023; Piumali et al., 2022), thus establishing the foundational principles for human-computer dialog.

The evolution continued with continuous technological advancements, which attempted to emulate natural human chat. The COVID-19 pandemic, beginning in 2020, acted as a catalyst for the rapid adoption of virtual healthcare delivery, accelerating the development of technology-enabled care solutions, as noted in early analyses by (Dingler et al., 2021). Considering recent digital shifts in healthcare, individuals are now prompted to monitor and uphold their health through daily observations of their health routines.

Engaging with conversational agents often yields valuable information, empowering humans to make improved decisions across various scenarios (Montenegro et al., 2022). Specifically, these CAs focus on influencing various health-related outcomes, including total physical activity, steps taken, moderate-to-vigorous physical activity, fruit and vegetable consumption, sleep quality, and sleep duration (Singh et al., 2023). There are several other advantages of CAs in daily life. CAs are available 24 hours a day to provide quick, reliable information and assistance if an individual is feeling unwell and wants to ask questions about health. In terms of emergencies, when individuals can't reach a doctor or nurse immediately, CAs ensure the initial guidance you need promptly, whether urgent medical attention is needed or not.

2.7 Health Conversational Agent (HCA) Architecture

Conversational agent architectures have been proposed in the literature with common and different components according to the system requirements. (Sureshkumar et al., 2022) proposed the HCA architecture within specific system requirements such as the user interface, natural processing language (NLP), APIs, health knowledgebase, dialog management components, sensor's data connectivity, and natural language processing (NLG), etc. Similarly, (Linders et al., 2022) proposed an agent architecture with specific system requirements according to the proposed research, such as an input channel, a messaging system, a dialog management system, NLP with classification, NLG, a behavioral generation system, and a virtual agent user interface.

Montagna et al. (2023) propose a system architecture comprising key components such as a recommendation engine, NLP/NLG modules, and adherence tracking, all interconnected via a REST API and user interfaces. As we can observe, current implementations of Health Conversational Agents (HCAs) demonstrate that their architectures are predominantly structured around immediate functional and system requirements. The focus remains on the technical functionality of components, specifying what exists and how they connect to process data and complete discrete tasks. This reveals a foundational gap: these architectures are designed as generic technical guidelines, lacking the explicit principles needed to systematically translate component functionality into measurable user empowerment. This limitation stems from an unclear conceptual bridge between technical design and human outcomes.

To properly frame this problem and establish the foundation for the solution, this research must first formalize what constitutes an architecture in this context. The following section (see section 2.9.1) provides this essential definition, which will allow us to precisely articulate the shortcomings of current approaches and the necessity for an empowerment architectural framework.

2.7.1. Health Conversational Agent System Architecture Definition

As discussed in Chapter 1, CAs are software systems with user interfaces that interpret user queries in different situations and communicate in a human manner (Johannes et al 2024). For example, in health CAs, users can ask about health conditions, symptoms, and get emotional support with health management tips as well. In terms of the definition of CA architecture, the description proposed by (Vandelanotte et al., 2023; Jabir et al., 2022) is formally defined as.

A CA architecture is a set of structures that enable reasoning about a system, including software elements, the relationships between components, and the rationale for how these component arrangements achieve user outcomes.

2.7.1.1 CA System Architecture Based on Components

When investigating HCAs from a component perspective, they can be categorized into generic CA architecture and architectures according to the system requirements. Generic or basic HCA architectures comprise main components, which include primary components or relationships between each other to provide basic functions at the user end, such as delivering health knowledge, recommendations, and sometimes emotional support as well. Although several architectures are mentioned in the literature (e.g., generic architecture, agent architecture, functional system architecture, and system architecture), they tend to be different according to the system requirements, with different terminologies but the same functions as proposed by (Farber et al., 2023; Hermawan et al., 2022; Muhammad et al., 2024; Montagna et al., 2023).

The components included in the HCA architectural components table (see Table 2.3) were identified and selected through a systematic process to ensure comprehensiveness and relevance to the research objective of enabling health empowerment. A literature review of health CA was conducted to catalogue all architectural components mentioned in existing systems and frameworks. This initial phase was inclusive, aiming to capture the full spectrum of technical components discussed in the field, from core NLP modules to specialized healthcare integrations.

Moreover, the components list was then critically evaluated against the empowerment relevance. A component was included if it could be directly mapped to one or more Health Empowerment Elements (HEEs). For example, a **Dynamic User Model** (a CA architectural component which is responsible for enabling personalized decision support and health management). To systematically address the gap between conversational agent architecture and health empowerment outcomes, this research first establishes a foundational taxonomy of core architectural components. The development of this taxonomy was guided by a systematic analysis of Health Conversational Agent (HCA) literature, focusing on identifying recurring technical elements across implementations. This process involved synthesizing component descriptions from diverse sources to create a unified framework that resolves terminological inconsistencies and establishes clear functional boundaries between different architectural elements.

Figure 2.3 illustrates the flow from user query as input to response generation by CAs. The flow begins with data pre-processing through Natural Language Understanding (NLU) to classify user intent and context, which utilises a Decision Support System, Rule Engine, and Explanation Engine to generate intelligent responses, often leveraging external APIs for enhanced functionality and medical context. The output of this intelligent processing is delivered to the user through multiple channels, including natural language, voice, and imagery facilitated by a Natural Language Generation (NLG) component. This closed-loop design is fundamentally geared towards delivering tailored, explanatory, and multi-modal interactions that support informed decision-making.

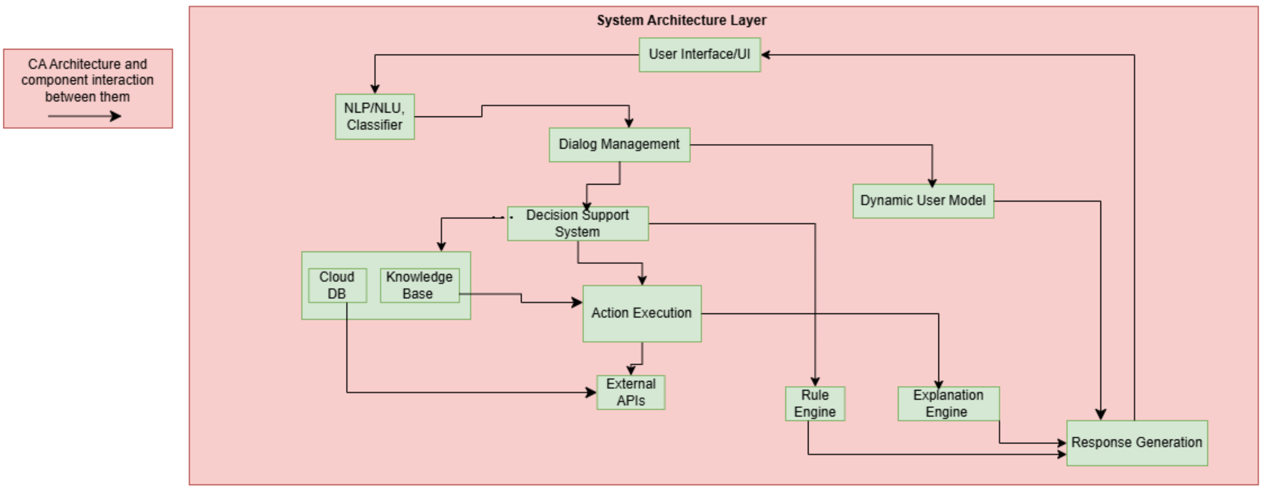


Figure 2.3: Interaction between HCA architectural components

2.7.2. Analysis of Implemented Empowerment and Architectural Gaps

Table 2.4 presents a systematic analysis of the literature on Health Conversational Agents (HCAs), structured to document the current state of health empowerment implementation and its underlying architectural support. It analyzes each study across the specific Health Empowerment Elements (HEEs) implemented and the architectural components used. This structured catalog provides an empirical baseline for understanding how empowerment is currently operationalized in CA design.

The principal analytical contribution of this table is presented in the "Identified Gaps" column. This column advances beyond mere feature cataloguing to systematically document two categories of systemic deficiencies: omitted Health Empowerment Elements (HEEs) and omitted architectural components. This dual-layered analysis reveals a direct causal relationship; the absence of core empowerment functions, such as personalized decision support or goal management, is consistently traced to the lack of specific technical components, such as a Dynamic User Model or a Recommendation Engine. This pattern provides tangible, evidence-based proof of the architectural fragmentation that this thesis aims to solve, demonstrating that current implementations are structurally incapable of delivering holistic health empowerment and thereby creating a compelling justification for the integrated mapping framework proposed in the subsequent chapter.

Table 2.3: SLR of HEEs and CA Architectural Components

Publication Reference	**Implemented Health Empowerment Elements**	**CA Architecture & Components**	**Identified Gaps Missing HEE: Missing Components:**
Sureshkumar et al., 2022	(Health Knowledge, Education and Support): Health Information, BP Checking Deciding (Personalized recommendations): Medication reminders (Monitoring and managing health goals): Sleep and heart rate monitoring, blood sugar level	System Architecture User, messenger interface, bot instance, context, knowledge base, database, NLP	**Missing HEE:** Motivational Support **Missing Components:** Decision support system, Chatbot API, Action execution, Dynamic user model, Sensor's data connectivity
Khadija et al., 2021	(Health Knowledge, Education and Support): Health information (not specified, human-like talk)	General Architecture User (Android Interface), Client platform, APIs, NLP Engine, Core Engine	**Missing HEE:** Motivation and support, Deciding (personalized recommendations), Monitoring and managing health goals **Missing Components:** Dialog management, Chatbot API, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine
Nie J et al., 2022	(Health Knowledge, Education and Support): Multiple 37 psychological dimensions, consolation Deciding (Personalized recommendations): Follow-up and Questions	System Architecture User input/output interface, psychological functions, chatbot room (NLP processing module), smartphone home devices and tracking devices	**Missing HEE:** Motivation and support, Monitoring and managing health goals **Missing Components:** Dialog management, Dynamic user model, Action execution, Explanation Engine
Montagna et al., 2023	(Health Knowledge, Education and Support): Patient engagement by query (Motivation and support):	System Architecture	**Missing HEE:** Deciding (personalized recommendations) **Missing Components:**

	Motivational messages (Monitoring and managing health goals); Self-management Improvement	(Admin and user interface, REST API, recommendation engine, daily and profile adherence, NLP, NLG, storage)	Dialog management, Action execution, Explanation Engine, Sensor's data connectivity
Linders et al., 2022	(Health Knowledge, Education and Support): Question answering, information access, and human-like communication	Agent Architecture Input channel (speech signal), Messaging System, Dialog Management system (Intent classification NLP, response generation NLG), Behaviour Generation System (speech synthesis), Virtual agent user interface	**Missing HEE:** Motivation and support, Decision (personalized recommendations), Monitoring and managing health goals **Missing Components:** Sensor's data connectivity, Action execution, Explanation Engine, Chatbot API
N & J et al., 2023	(Health Knowledge, Education and Support): User-friendly interface, guidance on various mental health topics, support, guidance Deciding (Personal recommendations): Individualized recommendations in terms of reminders for medication & appointments (Monitoring and managing health goals): Stress management	Architecture Diagram User Interface, user message analysis (intent and context information NLP), dialog management, action execution, information retrieval through dataset, response generation	**Missing HEE:** Motivation and support **Missing Components:** Sensor's data connectivity, Explanation Engine, Chatbot API, dynamic user model
Kamali et al., 2018	(Health Knowledge, Education and Support): Contextual information according to user preferences, Encouraging message Deciding (Personal recommendations): Recommendations of activities (Monitoring and managing health goals) Personalized coaching plans	System Architecture User profile, tangible device, multimodal coach bridge, chatbot engine, decision support system, Core/NLU	**Missing HEE:** Motivation and support **Missing Components:** Dialog management, Sensor's data connectivity, Explanation Engine, Chatbot API, dynamic user model

Jusoh et al., 2023	(Health Knowledge, Education and Support): Information about mental health and questions	System Architecture UI, User Question, Interface, Classifier, Knowledge-Based Module, Menbot Response	**Missing HEE:** Motivation and support, Deciding (personalized recommendations), Monitoring and managing health goals **Missing Components:** Dialog management, decision support system, Chatbot API, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine
Muhammad et al., 2024	(Health Knowledge, Education and Support): Health-related queries, symptom identification (Motivation and support): Emotional support through psychology Deciding (Personalized recommendations): Doctor recommendations, prescription generation, and appointment reminders	System Architecture User Interface, Text/voice input, Query processing, cloud database, NLP, Information (end user)	**Missing HEE:** Monitoring and managing health goals **Missing Components:** Dialog management, decision support system, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine
Hermawan et al., 2022	(Health Knowledge, Education and Support): Disease information retrieval, expert predictions	Functional System Frontend, Gateway, service monitoring (database), service expert system, service disease info (database disease), service user (user database), service chatbot, service chatbot actions	**Missing HEE:** Motivation and support, Deciding (personalized recommendations), Monitoring and managing health goals **Missing Components:** Dialog management, Dynamic user model, Sensor's data connectivity, Action execution

Färber et al., 2023	(Health Knowledge and education) (Definitions, further details, and multimedia content) (Motivation and support): Suggestions for encouraging behaviour Deciding (Personalized recommendations): Treatment options, follow-up consultations	Generic chatbot architecture Loop Art (Health Literacy Agent) (treatment plan, patient profile) Adherence agent (assessment and support (sensor data)) Conversational agent (information manager, advisory manager, education manager (user interface))	**Missing HEE:** Monitoring and managing health goals **Missing Components:** Dialog management, action execution, Cloud DB,
Angelini et al., 2022	(Health Knowledge, Education and Support): Helps well-being: physical, nutritional, social, cognitive and emotional Deciding (Personalized recommendations): Personalized activities and recommendations	System Architecture Coaching Interface: Apps & games, chatbot, tangible coach, Sensing units, Data processing (self-reporting), Decision Support System, Coaching activity, message db, Dynamic user model	**Missing HEE:** Monitoring and managing health goals, Motivation and support **Missing Components:** Explanation engine, action execution, Cloud DB
EI Kamali et al., 2020	(Health Knowledge, Education and Support): Contextual information according to user preferences, (Motivation and support): Encouraging message (Monitoring and managing health goals): Personalized coaching plans	E-Coach Architecture Tangible interface (speech API), ionic chatbot interface, mobile interface, User profile, multimodal coach bridge, conversational coach engine (emotional wellbeing engine), decision support system, Core/NLU	**Missing HEE:** Deciding (personalized recommendations), **Missing Components:** Explanation engine, action execution, Sensor's data connectivity, Dynamic user model
Bharti et al., 2020	(Health Knowledge, Education and Support): Healthcare education tips, interactive counselling sessions, and symptom coverage (Motivation and support): Encouraging suggestions Deciding (Personalized recommendations): Preventive measures, home remedies	System Architecture User interface, input app/device, dialog flow, intent, code, external app, DB, actionable data, output, etc.	**Missing HEE:** Monitoring and managing health goals **Missing Components:** Dialog management, decision support system, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine

Bhagchandani et al., 2022	(Health Knowledge, Education and Support): Information asking, Patient's virtual doctor, Illness identification	System Architecture User query> classification model (thought, behavior or emotion), patient health questionnaire	**Missing HEE:** Motivation and support, Deciding (personalized recommendations), Monitoring and managing health goals **Missing Components:** Dialog management, decision support system, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine
Bandopadhyay et al., 2023	(Health Knowledge, Education and Support): Healthcare questionnaire, disease prediction	Chatbot model User interface (Input/Output), speech-to-text conversion, text pre-processing, processed text fed into a neural network, output voice predictions (NLG)	**Missing HEE:** Motivation and support, Deciding (personalized recommendations), Monitoring and managing health goals **Missing Components:** Architectural components are not mentioned
Abdulrahman & Richards 2018., 2019	(Health Knowledge, Education and Support): Information types (modules) such as beliefs, medical history and family context Deciding (Personalized recommendations): Preferences (Monitoring and managing health goals): Planning goals	System Architecture Perception, Memory (autobiographical memory, knowledge base, user model), Emotion Appraisal, Plans, action selection, explanation engine (User info, planning goal, domain knowledge), logical rules, Action	**Missing HEE:** Motivation and support **Missing Components:** Dialog management, Dynamic user model, Sensor's data connectivity, Chatbot API
Lagakis et al., 2023	(Health Knowledge, Education and Support): Patient data collection (Monitoring and managing health goals): Appointment management and scheduling	System Architecture Administration and patient portal (Conversational Agent API)	**Missing HEE:** Motivation and support, Deciding (personalized recommendations), **Missing Components:** Architectural components are not mentioned
Marcolino et al., 2022	(Health Knowledge, Education and Support): Telehealth consultation with nurse, physician	Services System Architecture Tele covid app, database, data import, chatbot, patient (web or messenger app), and health professional access,	**Missing HEE:** Motivation and support, Deciding (personalized recommendations), **Missing Components:**

	(Monitoring and managing health goals) Actions for covid test request, home self-isolation, reports, and monitoring	teleconsultant interface, services dashboard (web app)	Architectural components are not mentioned.
Maia et al., 2023	(Health Knowledge, Education and Support): Preventive care offers information and advice (Motivation and support): Helping reminders Deciding (Personalized recommendations): Offers a cost-effective personalized and engaging solution; actions do	iCare4NextG platform Architecture User, Mobile Interface, Frontend (User Interaction, cognitive games) API gateway, AI Layer (Knowledge Base, User Health Status, Data Storage), OpenID, External Resources (Medical Devices, Prescription Software)	**Missing HEE:** Monitoring and managing health goals **Missing Components:** Dialog management, decision support system, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine
Preininger et al., 2020	(Health Knowledge, Education and Support): Medication-related questions, drugs usage, effects and pharmacological question-answering system	Watson chatbot integrated with Micromedex architecture Clinician/User interface, Micromedex on HIDS, Rest APIs, Conversation Manager (Business logic), Watson Assistant, update service, cloud DB, conversation logging, internal operations (Test UI)	**Missing HEE:** Motivation and support, Deciding (personalized recommendations), Monitoring and managing health goals **Missing Components:** Decision support system, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine
Denecke et al., 2023	(Health Knowledge, Education and Support): Medical history access (Shape, mass density) (Motivation and support): N/A Deciding (Personalized recommendations): Redirect to doctors for further actions	Reference DMIA architecture User, Chatbot-Module, conversational protocol, free text analysis, NLP module, Structured Information Content definition (professional), Admin Module (assistant), Workflow engine > Input/data	**Missing HEE:** Monitoring and managing health goals **Missing Components:** Decision support system, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine

Thomas et al., 2023	(Health Knowledge, Education and Support): Gives depression level, face detection, and camera sensors identify the stress level Deciding (Personalized recommendations): Recommendations and chat texts	System Architecture Input data (FER 2013 Dataset, preprocessing, data split; Live Video, face detection, external face ROI), VGG model, Face emotion (Sentiment140 dataset, preprocessing, split, Bayes theorem), depression classification, provide recommendation, chatbot, user input	**Missing HEE:** Motivation and support, Monitoring and managing health goals **Missing Components:** Architectural components are not mentioned
Katariya et al., 2019	(Health Knowledge, Education and Support): General information about symptoms, surveys, and medical history (Personalized recommendations): Specific disease prevention pathways	System Architecture User, messaging platform health Bot, NLP, Bot logic, information sources (Data Lake, API from partners, human intervention), actions, ML	**Missing HEE:** Motivation and support, Monitoring and managing health goals **Missing Components:** Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine
Ayanouz et al., 2020, 2021	(Health Knowledge, Education and Support): Health questions answers (not specified) Deciding (Personalized recommendations): Chat with the doctor.	General Architecture Environment {(NLP [Intent classifier, entity extractor])}, {(Dialog Management [policy learning, Feedback mechanism])}, Question Answering System {(manual training, structured knowledge bank, automated training)}, ServiceNow System {(Client-specific Table APIs, Tickets Creation Flow (intelligent automation engine), Ticket Creation Flow, Knowledge Articles)}, Node Server {Template response for actions, based on client, Feedback from user for re-training}, Interface>User	**Missing HEE:** Motivation and support, Monitoring and managing health goals **Missing Components:** Decision support system, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine
Roca et al., 2020	(Health Knowledge, Education and Support): Patient's activity summary	General Chatbot Architecture	**Missing HEE:** Motivation and support, Monitoring and managing health goals **Missing Components:**

	CA asks for a questionnaire to collect users' health data for chronic diseases (Personalized recommendations): Medical appointments	User Communication (Devices with messaging app, Messaging platform server, proxies, and logging) API gateway, Data storage (EHR), Chatbot microservices (functions, data processing) Access control, Monitoring	Decision support system, Action execution, Dynamic user model, Sensor's data connectivity, Explanation Engine

2.8 Literature Findings & Conclusions

As established in the preceding systematic review, achieving genuine health empowerment through conversational agents requires carefully designed system architectures that embed empowerment as a core design principle. However, our analysis reveals a fundamental disconnect between technical implementation and empowerment outcomes. The literature shows consistent fragmentation in how HEEs are implemented across CA architectures, with most solutions addressing only isolated aspects of the empowerment process rather than providing comprehensive support.

The evidence from our systematic literature review table (see Table 2.3) demonstrates that current CA implementations exhibit significant gaps in both empowerment coverage and architectural completeness. While individual studies successfully implement specific components such as NLP engines or knowledge bases for information delivery, our analysis of "Missing HEEs" and "Missing Components" reveals a consistent pattern: architectures that provide health knowledge typically lack motivational support modules, and systems with sensor data connectivity often omit goal-setting capabilities. This fragmentation directly limits their ability to support the complete empowerment journey from knowledge acquisition to sustained behaviours change.

This architectural limitation persists despite the availability of advanced technologies. While developers typically reference standard architectural frameworks focusing on technical components and their interactions, these blueprints offer no guidance for systematically achieving empowerment outcomes (Pietrantoni et al., 2023). The emergence of large language models and sophisticated deep learning approaches makes this gap particularly pressing; these technologies enable more adaptive interactions but require architectural guidance to ensure they support empowerment systematically rather than perpetuating existing fragmentation (Lo & Lee, 2017).

Critically, this research analysis confirms that no existing architecture demonstrates how coordinated components can jointly address the multidimensional nature of empowerment encompassing knowledge, personalization, emotional support, and self-management (Sanjeewa et al., 2024). The systematic gaps identified in Table 2.4 show consistent absences of key components such as dynamic user models, sensor data connectivity, external API connections, and explanation engines across implementations, providing empirical evidence that current approaches are structurally incapable of delivering holistic empowerment.

This underscores the necessity for a unified framework that explicitly maps architectural components to empowerment elements, ensuring future CAs can be designed with empowerment as an inherent architectural property rather than an incidental feature.

2.9 Theoretical Foundations for Framework Design

This research is grounded in established theoretical concepts to guide the design of the artifact in accordance with Design Science Research Methodology. For this purpose, several key theories have been identified from the literature to ensure a rigorously grounded, human-centric design approach [reference count]. The foundational theory is health empowerment, which encompasses improved individual performance and enhanced involvement in decision-making processes. **Health Empowerment Theory** significantly informs the design of conversational agents (CAs) in healthcare by shifting the focus from mere information delivery to fostering user engagement and promoting self-management. By integrating its principles, CAs can facilitate personalized interactions, support sustainable behavior change, and ultimately improve health outcomes.

Self-Determination Theory (SDT) serves as the central motivational model that operationalizes empowerment. SDT asserts that individuals actively pursue behaviors and activities that foster personal growth and a coherent sense of self (Ramos et al., 2023; Martela et al., 2021). This theory aligns directly with empowerment concepts and comprises three core psychological needs essential for the CA empowerment framework design principles:

- **Autonomy:** The need for user control and choice over their health journey
  Link with SDT: User control & choice can be implemented by the Dynamic User Model and Dialog Manager components.
- **Competence:** The need for users to feel effective in managing their health
  Link with SDT: Sense of knowledge, feeling involved, and being effective can be implemented by the Explanation Engine, Knowledge Base, and Progress Tracking components.
- **Relatedness:** The need for a sense of connection and support.
  Link with SDT: Sense of connection and supportive interaction can be implemented by the Dialogue Manager and Behaviour Generation System components.

The application of SDT is well-established in health contexts. For instance, the link between SDT and the CA architecture is established through operationalization. Each of the three core psychological needs is translated into a specific design requirement, which in turn informs the selection and function of specific architectural components. However, a theoretically sound CA is ineffective if rejected by users. This is where the **Technology Acceptance Model (TAM)** provides a crucial complementary perspective. For empowerment to occur, users must perceive the CA's interface as clear, easy to use, and trustworthy. AlQudah et al. (2021) confirmed that TAM is the predominant model for explaining user acceptance of healthcare technologies across diverse populations and settings. Technology acceptance, defined as the positive decision to use an innovation, is vital. TAM ensures that the design prioritises perceived usefulness and perceived ease of use, which are prerequisites for engagement and, consequently, empowerment.

Finally, to convert motivation support into actionable steps, **Behaviour Change Theories (BCT)** are there to provide the mechanistic framework. These theories guide the intervention's structure and help monitor participants' progression through different 'stages of change' (Martinengo et al., 2022). All these theories have been summarised in the mentioned Table 2.4 with description and their application in this research.

Table 2.4: Conceptual Theories for the Research

Theory	**Description**	**Application in Research**
Health Empowerment Theory (HET)	HET significantly informs the design of conversational agents (CAs) in healthcare by shifting the focus from mere information delivery to fostering user engagement and promoting self-management.	Used its core principles to facilitate personalized interactions, support behaviour change, and improve health outcomes
Self-determination Theory (SDT)	SDT used for human motivation and its interpersonal determinants, effective communication which involves the delicate combination of providing rules and structure in a caring and autonomy-supportive way	Used in terms of three actionable design requirements: supporting user choice (autonomy), competence (building efficacy), and relatedness (motivational support)
Technology Acceptance Model (TAM)	It defines as positive decision to use an innovation. TAM designs prioritize perceived usefulness and perceived ease of use, which are prerequisites for engagement and, consequently	Ensured the proposed framework prioritizes perceived usefulness and ease of use
Behavioural Change Theory (BCT)	Provides guidelines about problem solving, action planning behaviour, self-monitoring of behaviour, social support (emotional), information about	Used as guidelines to design CA framework though stages of change at user end (e.g., goal setting, tracking, maintenance)

	health consequences, and instructions on how to perform behaviour	

The following Figure 2.4 illustrates the conceptual model of the integrated theoretical foundation underpinning the design of this research's artifact. It illustrates the hierarchy and interplay between four core theories, demonstrating how each contributes a unique and essential perspective to the creation of a comprehensive, human-centric design tool.

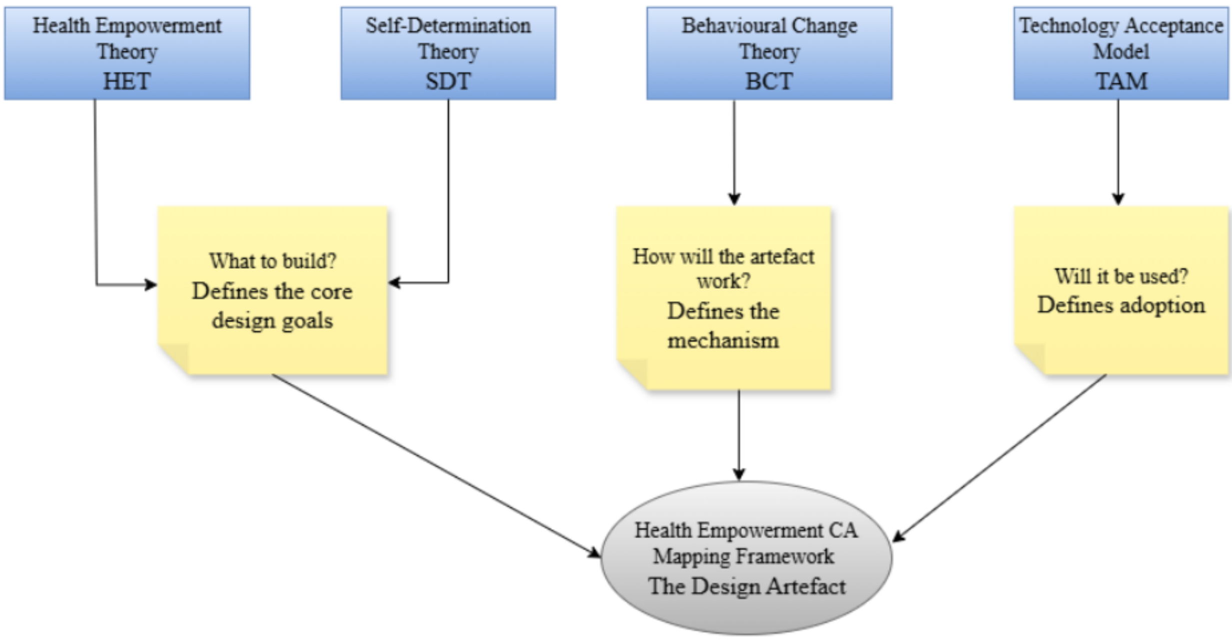


Figure 2.4: Theoretical Foundation of the Mapping Framework

This chapter is provided according to the literature review of different methodologies, literature review methods. Moreover, this chapter providing theoretical concepts to develop the health CA empowerment mapping framework. Subsequently, Chapter 3 will provide the application of DSRM in this research with phases.

Chapter 3: Research Methodology

This research is grounded in the design science research (DSRM) methodology, which represents a problem-centred solution approach. Characterised as a pragmatic, problem-solving paradigm, DSR contributes to human knowledge by creating innovative artefacts (Hevner et al., 2007). The DSRM is vital in guiding this research by following its phases. The structure of this thesis is also organized based on these phases. Chapters 1, 2, and 3 are related to the first two phases, and Chapter 4 links to the last two phases. The details are illustrated in Figure 3.1.

3.1 Design Science Research Method (DSRM)

After decades of development, DSRM has been proposed and applied in the literature, demonstrating various models and techniques for structuring research study processes. (Hevner, 2007) proposes three cycle processes, which include the relevance cycle, the design cycle, and the rigor cycle to manage and complete the research projects. Peffers (2020) proposed a "problem-centered approach" (Peffers et al., 2020), the methodology includes six phases, starting with identifying a problem and deriving a motivation for its solution. The methodology includes research objectives, design and development of artifacts, evaluation and demonstration, and communication of research steps. Offermann et al (2009) provide 11 processes in three phases: problem identification, solution design, and evaluation. Similarly, the design process can be analytically structured to comprise a sequence of cycles, drawing on Kuechler and Kuechler (2008). These are the cycle of (1) problem awareness, (2) design suggestions, (3) development, (4) evaluation, and (5) conclusion. All of these methodologies have similar phases and processes that can be used to contextualise, design, and evaluate artefacts.

The primary output of this thesis is a **conceptual framework**: a mapping that provides structured logic for designing empowerment-oriented CA architectures. This type of artifact requires a tailored validation strategy. Therefore, the current work focuses on the **design & and development and evaluation** of the artefact, a validation of the artefact's theoretical soundness and internal consistency through structured methods before empirical deployment.

The includes:

- **Establishing Theoretical Grounding:** Ensuring the framework is built upon established knowledge (Self-Determination Theory, empowerment theory).
- **Ensuring Internal Consistency & Utility:** Using expert feedback and logical analysis to verify the framework's coherence and potential usefulness.

3.2 Research Application Based on Design Science

The application of DSRM ensures the iterative development of the artefact to yield a robust and practical solution (Beinke et al., 2019). The sections below illustrate how this methodology is applied across the six phases of the DSRM process, integrating techniques from complementary approaches such as literature reviews and artefact proposal to enhance the execution of this study. To answer the research questions, the DSRM approach of Peffers et al. 2007, 2020 has been adopted. The subsequent sections provide a detailed explanation of these phases. These phases include problem identification and motivation of research, objective of a solution, artefact design and development in terms of proposed research output, evaluation and demonstration of proposed solution and communication of research, etc. The specifics and procedures used in this study are illustrated in Figure 3.1, which provides an overview of the six-step technique.

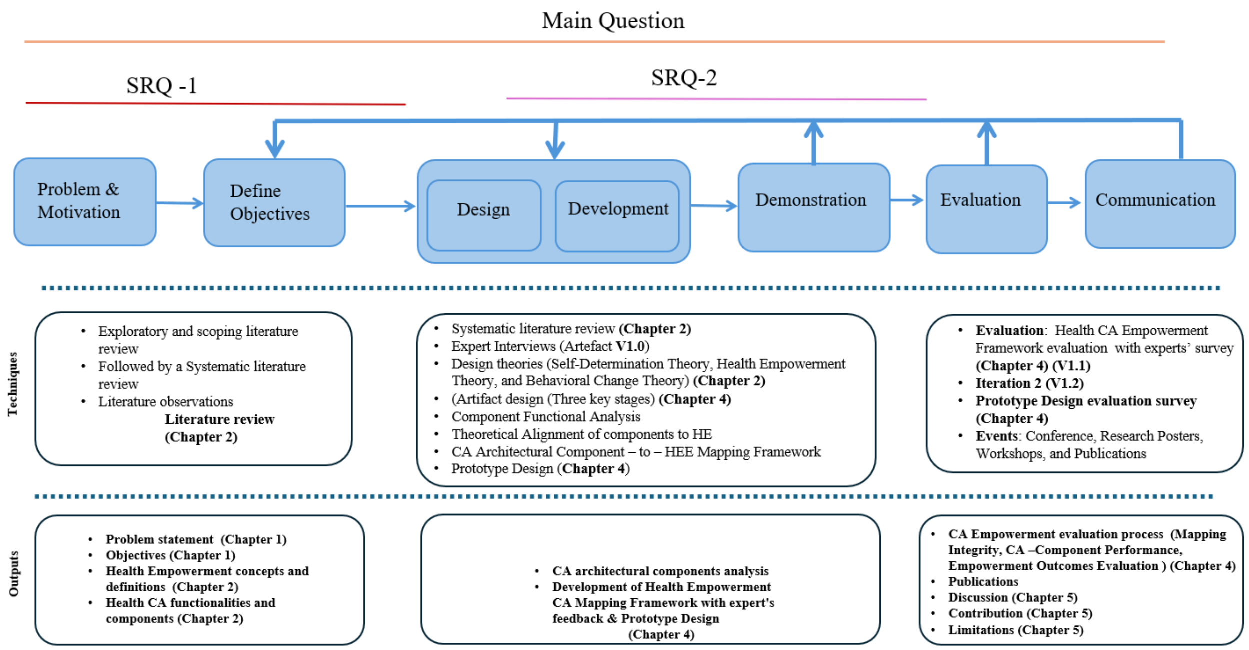


Figure 3.1: The methodology adopted for this research (adapted from Peffers 2007, 2020)

3.2.1 Identifying the Problem, Motivation, and Research Objectives

The initial phase of this research involves identifying the core research problem. This phase aims to pinpoint the research gap, formulate precise research questions, and contextualise the health empowerment problem within real-world scenarios, explicitly focusing on CA user-facing functionalities and underlying architectural components. The first phase of DSRM followed a problem-centred initiation, rigorously defining the research scope through a multi-stage process. Chapter 1 summarised the core problem by identifying a critical gap: the disconnection between Conversational Agent (CA) architectures and measurable health empowerment outcomes. This was achieved by contextualising the research problem and analysing the limitations of current CA functionalities and related CA architecture components. From this problem definition, the primary research objective and the Main Research Question (MRQ) were formulated to guide the subsequent inquiry.

Chapter 2 transitioned from problem definition to solution design by constructing the necessary theoretical foundation. This involved a systematic literature review to formally define the core constructs of health empowerment (HE) and CA architectures. The analysis conducted in this chapter was explicitly structured to answer the first two Sub-Research Questions:

- **SRQ1** focused on identifying and standardising the key Health Empowerment Elements (HEEs), which were addressed through a thematic synthesis of the literature. (see Figure 3.1 for DSRM phase)

- **SRQ2** investigated the relationship between CA components and HEEs, which was explored by systematically analysing and coding existing research for implicit and explicit links. (see Figure 3.1 for DSRM phase)

The output of this phase is a precisely defined problem space and a set of foundational constructs, which directly inform the objectives for a solution and the design of the primary artefact, the mapping framework.

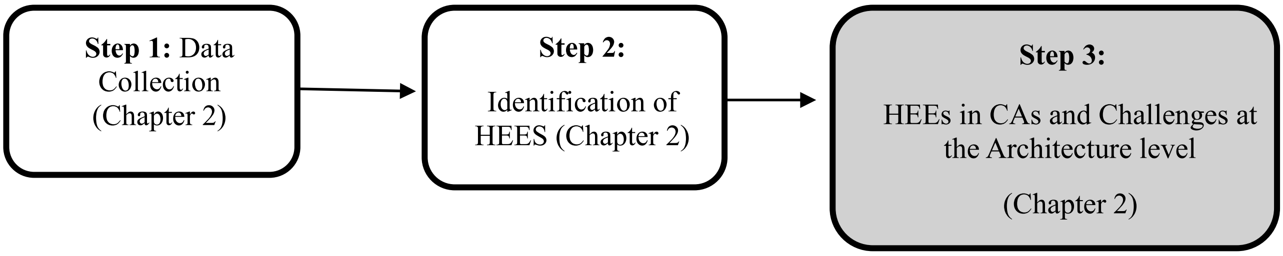


Figure 3.2: Method to answer the Problem Identification & Research Objectives phase of DSRM

3.2.2 Design & Development and Evaluation

Following the identification of the problem and definition of the objective, the Design and Development phase focuses on developing the research artefact. The primary artefact of this study is the framework design, which maps conversational agent components to health empowerment elements. The framework is constructed through a systematic process: first, synthesizing Health Empowerment Elements (HEEs) from established psychological theories; second, deriving a functional taxonomy of CA components from technical literature; and finally, establishing theoretical linkages between these components and the HEEs they are designed to support. This structured mapping provides developers with actionable guidance for implementing empowerment-oriented features and offers researchers a validated model for measuring psychosocial outcomes. The primary contribution is thus a novel, theoretically-grounded blueprint for the design and evaluation of next-generation health conversational agents. The development of this artefact is guided by the methodological steps outlined below.

These steps are conducted in Chapter 4, where the two Sub-Research Questions (SRQs) are addressed alongside proposed solutions. To address SRQ1, a scoping review was first conducted to reveal key health empowerment elements and relevant CA functionalities enabled by architectural components. Subsequently, a systematic literature review identified gaps in existing research regarding CA architectures. The review indicated that health empowerment-oriented CA components were often implemented in a generic manner. Furthermore, the full potential of identified health empowerment elements and corresponding architectural components remains unrealized, hindering personal health empowerment when using health conversational agents. This gap underscores the need for further research and artifacts such as a mapped CA architecture aligned with health empowerment elements.

For SRQ2, a framework is developed to illustrate which CA architectural components relate to health empowerment and their impact on user-end healthcare functionalities. The development of an artifact is divided into three main stages (see Chapter 4). The development of the mapping framework artifact followed a systematic, three-stage methodology. It began with a functional analysis to deconstruct the capabilities of standard CA architectural components. Subsequently, a stage of theoretical alignment assessed how each component's function could operationally support the theoretical constructs of the Health Empowerment Elements (HEEs). This process was achieved in the CA component-to-HEE mapping stage, where definitive connections were established between components and HEEs, forming the core of the proposed framework (see Chapter 4, artefact V1.0). For rigor cycle in DSRM, the artefact has been evaluated with software solution architect experts through interviews (see Chapter 4, artefact version V1.1).

Building upon the validated framework, a functional prototype of the Health Conversational Agent was developed to instantiate the proposed architecture. This prototype operationalizes the four core empowerment functions derived from the HEEs: **Understand, Decide, Motivation, and Manage**. The prototype serves as a proof-of-concept instantiation, demonstrating that the abstract framework is technically realizable and that its core components such as the Dynamic User Model, Explanation Engine, and Motivational Support Engine can be operationalized in a working system.

The steps followed in this phase of DSRM are shown below in Figure 3.3.

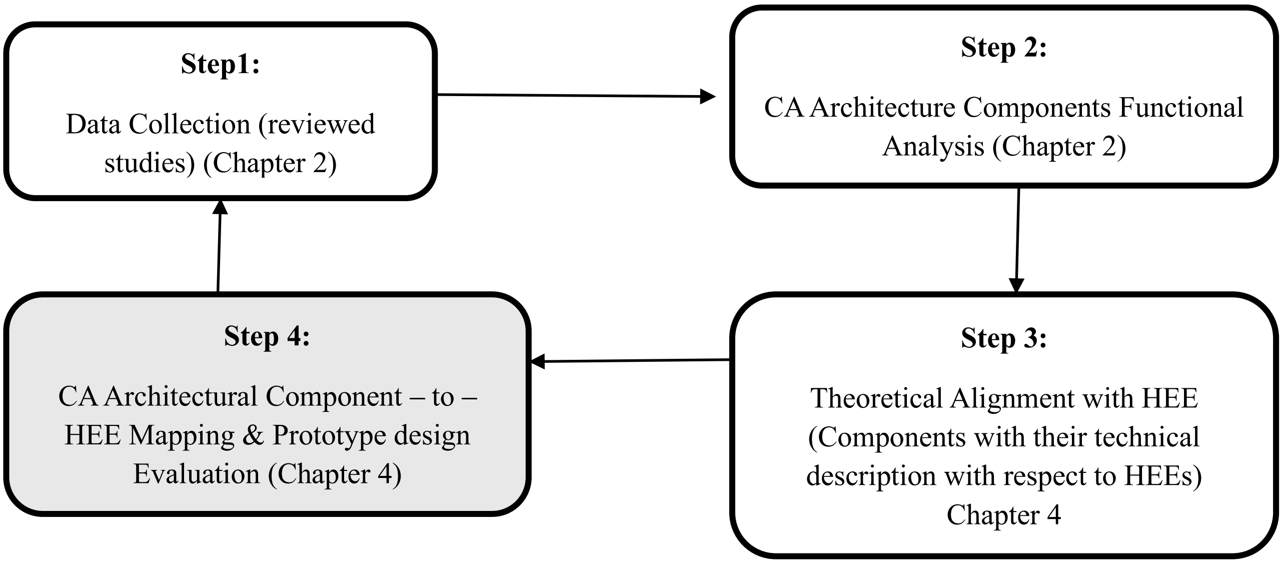


Figure 3.3: Method to answer the Design & Development phase of DSRM

An expert survey was conducted to evaluate the proposed framework's practical utility and conceptual soundness. The survey targeted professionals specializing in software solution architecture and AI in healthcare, a group selected for their direct involvement in system design and development. The evaluation specifically assessed the framework on key criteria: the efficacy of its proposed mappings, its utility for guiding design decisions, and the logical consistency and completeness of its defined CA architectural components. The collected feedback and its detailed analysis, which is presented in Chapter 4, provided empirically grounded insights for refining the artifact. This evaluation directly informed an iterative update, resulting in the subsequent and improved version of the framework, designated as V1.2 with presented prototype design (see section 4.7).

3.2.3 Demonstration & Communication

As mentioned, this research is designed in accordance with DSRM. In DSRM, demonstrating work and communication is very important to obtain experts' reviews and requirements to design artifacts. Hence, this research has actively disseminated findings through multiple academic and industry engagements, including a peer-reviewed workshop publication at Mensch und Computer 2024, poster presentations at LERO Summit (2023-2024) and Innovation Value Institute Summit (2023-2025), and invited presentations at Maynooth University's CS postgraduate workshops (2024-2025). The work has also been showcased through competitive poster presentations at the Digital Business Research Day (University of Coimbra 2024) and Maynooth University (2025). This comprehensive dissemination strategy has facilitated valuable feedback and strengthened collaborations with academia in the digital health domain.

Chapter 3 presented the Design Science Research Methodology as the guiding paradigm for this thesis, providing the structured framework for artefact creation and evaluation. The research has been systematically conducted in alignment with this methodology, beginning with the Problem Identification and

Motivation phase, as outlined in Chapter 2, which established the critical gap in the literature through a systematic review. This was followed by the Objectives of a Solution phase, where the conceptual model in Chapter 2 synthesised theoretical foundations into defined design goals.

The subsequent Chapter 4 will present the primary artefact and complete the final DSRM phases. It will show in detail the Design and Development of the Health CA Empowerment Mapping Framework, demonstrating how the conceptual model was operationalised. Finally, it will conclude in the Evaluation phase, proposing a rigorous, multi-method validation strategy to assess the framework's completeness with experts' views with instantiated prototype design of CAs. Thus, the following chapter represents the conclusion of this systematic process, delivering a novel design artefact aimed at bridging a critical gap in health-centric conversational agent architecture.

Chapter 4: Proposed Artefact (Health Empowerment CA Mapping Framework)

This chapter is related to three DSRM phases (design, development, and Evaluation). An examination of the literature reveals that no existing framework provides comprehensive mapping between CA system architectural components and specific health empowerment elements. Current system architectures treat technical components as standalone features rather than as interconnected elements of an empowerment-focused system. This gap has tangible consequences: for instance, without an explicit link between a Dialogue Manager (component) and Motivational Support (HEE), a CA may fail to employ evidence-based techniques such as motivational interviewing, thereby missing critical opportunities to enhance user self-efficacy and engagement in their health management.

A recurring critique in the literature is that system architectures often prioritize technical functionality over human-centric outcomes, treating components as standalone features rather than interconnected elements of a holistic user experience, such as motivational support, personalized health decision-making, and health management (Shneiderman et al., 2020). This architectural shortcoming, when applied to (CAs), has demonstrable consequences that hinder user empowerment. This architectural gap directly undermines the efficacy of (CAs). For example, a CA's documented inability to sustain long-term engagement (Liao et al., 2021) stems from a common architectural flaw: the absence of a Dynamic User Model explicitly designed to track and respond to a user's evolving empowerment journey. When architectural components are not mapped to theoretical HEEs, such as linking a user model to the development of competence (Ramos et al., 2023), the resulting system lacks the theoretical foundation necessary not only to foster empowerment but also to measure its impact.

Without such theoretical foundations, developers often lack guidance on how to architect CAs that truly empower users, and researchers struggle to systematically evaluate the outcomes of empowerment. The development and evaluation of health conversational agents (HCAs) are currently constrained by the absence of a unifying theoretical model. This gap results in architectural designs that lack a principled basis for fostering user empowerment and complicates the selection of meaningful evaluation metrics. To address this limitation, this research introduces a structured framework (see section 4.1) that explicitly maps HCA architectural components to core constructs of health empowerment.

4.1 Mapping Framework: Artefact

This artefact presents the core methodological output of this research: a systematic mapping of the CA architectural components to a synthesised framework of HEEs. Ultimately, the primary objective of this phase of research is to design a detailed mapping of the proposed research artefact. The research artefact was conducted in several stages (see phases 1, 2, and 3 below, with components mapped to health empowerment elements).

4.1.1 Mapping Process

The mapping between CA architectural components and (HEEs) was established through a systematic, directed process. The proposed mapping framework is grounded in empowerment theory and Self-Determination Theory (SDT), which provide the theoretical lens for understanding 'why' specific architectural components are linked to empowerment outcomes (see Chapter 2 for explanation). This theoretical foundation ensures that the framework moves beyond technical functionality to address core psychological needs, autonomy, competence, and relatedness that are essential for genuine health empowerment. This methodology ensured that each technical element was rigorously linked to the human-centric outcomes it was designed to enable. The mapping methodology consists of several key stages

The process consisted of three key stages:

- **Component Functional Analysis:** Each CA architectural component (e.g., Dynamic User Model, Dialogue Manager, Explanation Engine) was analysed to define its core technical capabilities and outputs (see Table 2.1 for explanation). (stage1)
- **Theoretical Alignment:** This stage of the mapping process established a theoretical alignment between the (CA) architectural components and the (HEEs). This alignment was derived from the conceptual framework for HEEs developed in Chapter 2 (Figure 2.1) and supported by established literature on health CAs. For instance, the component of Dialogue Management was theoretically linked to the HEEs of Health Knowledge & Support and Decision-Making through personalised recommendations. This linkage is justified by the work of Färber et al. (2023) and Sureshkumar et al. (2022), which demonstrate that adaptive, context-aware dialogue is a critical mechanism for delivering personalised information and facilitating shared decision-making, both of which are core elements of the respective HEEs. Each component's functional output was systematically evaluated against the formal definitions and theoretical constructs of the HEEs (see Table 4.1 as an output of this stage) to ensure conceptual consistency before empirical validation.

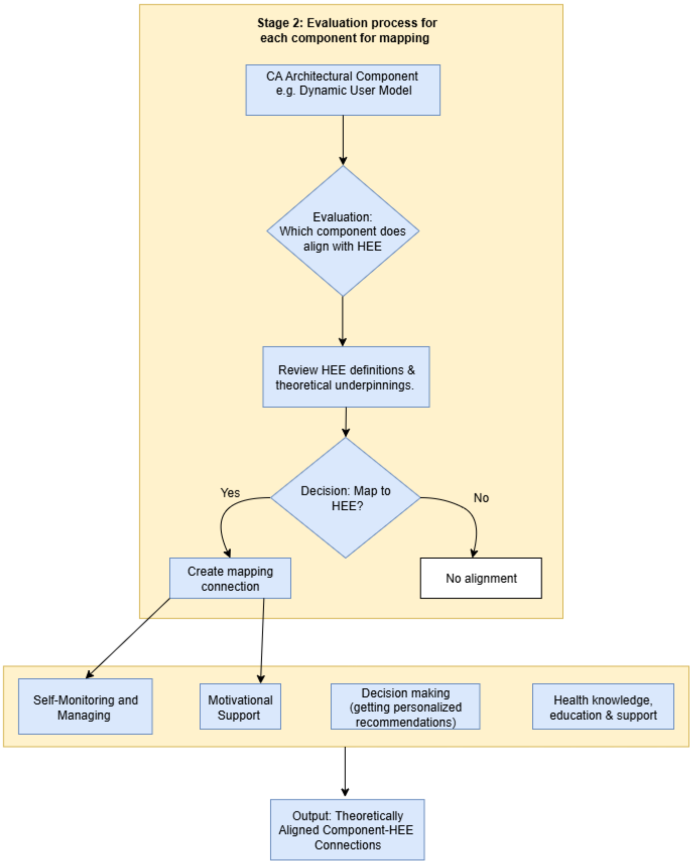


Figure 4.1: Theoretical alignment of components -HEEs (stage 2)

The following Table 4.1 presents the results of a systematic mapping process that connects the core technical components of a CA to key elements of health empowerment. Its primary purpose is to validate that the technical design directly supports the human-centred goal of empowering users. This process ensures that every technical decision can be traced to a specific, user-beneficial outcome, creating a cohesive, purposeful system.

This table (Table 4.1) was established through a structured theoretical methodology as presented above (see Figure 4.1). First, we identified the essential technical architectural components of a CA, such as its Natural Language Processing (NLP) engine and Dialogue Management system. Finally, we conducted a systematic analysis, evaluating each technical component (section 1.1.2, used as the component description from Chapter 1) against each empowerment element (Figure 2.2, used as the HEE description from Chapter 2). A checkmark (✓) was placed only where a component was deemed functionally necessary or highly integral to delivering that specific form of HEE in terms of user support.

The prevalence of checkmarks across the table reveals a fundamental insight: health empowerment is an emergent property of the CA's integrated architecture, not the function of a single part. This interconnectedness shows that the components work in concert. For instance, providing a personalized recommendation requires the NLP to understand a user's request, the Dialog Manager to maintain context, and the Decision Support System to generate the advice. This demonstrates a holistic design where the entire system is structured to be inherently supportive and empowering.

Table 4.1: CA Architectural Components with corresponding HEEs (Mapping)

CA Components	**Health Knowledge, Education & Support**	**Motivational Support**	**Decision-Making (getting personalized recommendations)**	**Self-Monitoring and Managing**
User Interface	✓	✓	✓	✓
Natural Language Processing (NLP)	✓		✓	✓
Classifier Info/NLU	✓		✓	✓
Dialog management	✓		✓	✓
Decision support system		✓	✓	✓
Chatbot API			✓	
Action execution	✓			✓
Dynamic user model		✓		✓
Rule engine	✓			

Health knowledge base expert/expert system	✓		✓	
Explanation Engine	✓		✓	
Cloud/Service DBs	✓		✓	
Sensor's data connectivity			✓	
Natural language generation (NLG)	✓	✓	✓	✓

Crucially, the mapping acknowledges that components often support multiple HEEs synergistically; for instance, a well-designed Explanation Engine simultaneously promotes health understanding and decision-making support by enabling informed choice at the user end (see Table 4.1). This complete theoretical map thus provides a foundational set of testable propositions for subsequent empirical validation and refinement. By making these relationships explicit, Table 4.1 confirms that our CA's design is both theoretically grounded and functionally coherent, ensuring the final product is truly empowering for its users.

This table offers a precise functional specification, outlining for each core component, the HEEs it connects to and a detailed account of its role in producing user-focused health outcomes. It transforms the conceptual connections from the mapping into a concrete design plan, showing how each part of the architectural system enables a specific aspect of user empowerment. This establishes a clear, logical connection between the CA's technical implementation and its intended effects. This framework is the direct result of the analysis performed in the previous section (Section 4.1). The above mentioned HEEs listed are defined concepts taken from the theoretical foundations reviewed in Chapter 2. Therefore, Table 4.1 provides clear evidence that the HEEs have been methodically and transparently incorporated into the CA's architecture.

CA Architectural Component to HEE Mapping: After the theoretical alignment stage, the comprehensive mapping shown in Figure 4.2 illustrates the proposed connections between all defined CA architectural components and their respective HEEs. The mapping framework serves as a visual representation of technical functionalities intended to foster HEEs as human-centric health outcomes, as later described in Table 4.1. Each linkage within the framework is developed as a functional relationship, derived from the conceptual theoretical framework of HEEs and substantiated by prior empirical work on the technical capabilities of CA architectures. For instance, the component 'Dialogue Management' is linked to the HEE 'Informed Decision-Making,' based on established theory that adaptive interaction is a prerequisite for processing complex information and forming behavioral intentions. This structured mapping establishes a verifiable chain of traceability, directly linking the implementation of specific technical components to the attainment of targeted health empowerment outcomes at the user level.

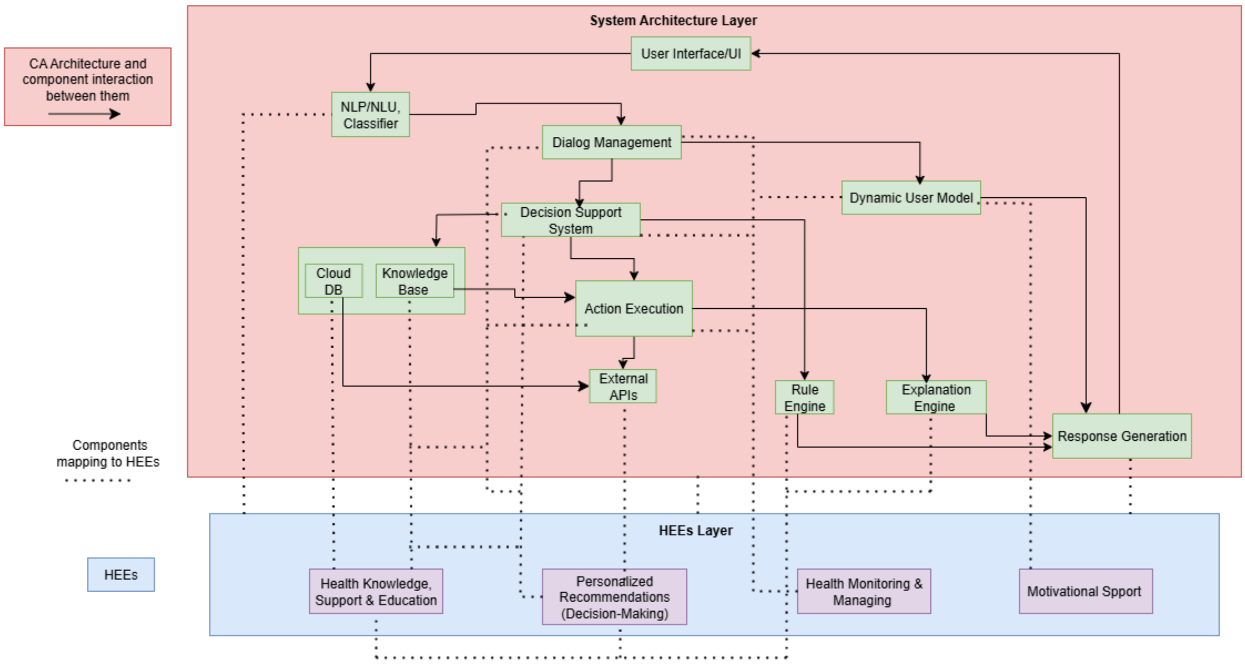


Figure 4.2: Architectural component to HEE mapping framework (V1.0)

Within the Design and Development phase of the DSRM, a formal evaluation of the research artifact was conducted to assess its initial conceptual integrity and utility. The evaluation strategy employed expert reviews, engaging a panel of software solution architects and principal software developers to critically examine the artifact's construct validity and practical applicability. The evaluation criteria were derived from established design science frameworks (Sonnenberg & vom Brocke, 2012), selected for their comprehensive coverage of key artifact attributes, namely completeness, feasibility, and actionability.

Data collection was carried out through semi-structured interviews administered via the Microsoft Teams platform. The interview transcripts underwent a systematic thematic analysis to extract qualitative insights, identify critical issues, and gather constructive recommendations for artifact refinement. The subsequent Table 4.2 documents this evaluative process, mapping expert feedback against the core evaluation criteria and outlining the corresponding iterative modifications implemented in the artifact. This systematic validation and refinement process resulted in an enhanced version of the framework, subsequently designated as v1.1 (see Figure 4.3).

Table 4.2: Experts Feedback on V1.0 Artefact (Design & Development)

Evaluation Criteria	**Input & Method**	**Expert Feedback**	**Action Taken (Framework Iteration)**
Clarity & Scope	Input: Initial Framework v1.0 Method: Interview with Expert 1(Software Solution Architect)	**Feedback:** The expert clarified the critical distinction between **"Functional Architecture"** (what the system does) and **"Technical Architecture"** (how it is built, e.g., specific servers, databases). **Analysis:** The framework's purpose and scope were ambiguous. It was incorrectly positioned as describing "technical capabilities" when its true contribution is defining the *functional capabilities* required for empowerment.	**Refined Framework v1.1:** The framework's description and scope were explicitly defined as a **"Functional Architecture"** blueprint. **Justification:** This precise terminology aligns with industry standards and sharply defines the artifact's boundary, preventing misinterpretation. It clarifies that the framework prescribes what is needed, not how to build it.
Actionability	**Input:** Mappings in Initial Framework v1.0 **Method:** Interviews with Both Experts	**Feedback:** Experts discussed concrete implementation details: 1. **Expert 1** mentioned protocols and different components, such as the profile dashboard. 2. **Expert 2** emphasised the importance of a **Knowledge Base** with vector databases and showed component interaction. **Analysis:** The framework was conceptually sound but lacked hooks to bridge the gap between high-level design and practical implementation.	**Refined Framework v1.1:** 1. **"Knowledge Base"** was explicitly added as a critical data store component. 2. User profile dashboard was added in V1.2.
Internal consistency & Understandability	**Input:** Visual Architecture Diagram **Method:** Interview with (Solution Architect)	**Feedback:** The expert critically reviewed the visual representation, pointing out that the **"links or arrows are not correct within the architecture and use a professional tool to design architecture"**	**Refined Framework v1.1:** The architecture diagram was **redesigned** to correct the component interactions and data flows with an online available professional designing tool such as

		Analysis: The diagram's data flow and interaction paths between components were logically flawed or unclear. This undermined the framework's **internal consistency** and **understandability**, as the visual model did not accurately represent the proposed system's behavior.	Eraser (https://www.eraser.io/ai/architecture-diagram-generator). A greater emphasis was (as suggested by the expert) to formally define the step-by-step interactions between the User Interface, NLP, Dialog Management, and other components.

The systematic analysis of experts' feedback and finalised targeted refinements to the initial framework (v1.0). Convergent insights from the expert reviews identified critical areas for improvement, specifically about the framework's **architectural completeness**, **terminological precision**, and the **logical coherence** of its conceptual model.

An iterative refinement process was subsequently undertaken to address these insights. Key modifications included the explicit integration of dedicated **components such as service DB**, a clarified scope delineating the framework as a **functional architecture**, and a revision of component interactions within the accompanying visual model to ensure accurate representation of data flows and dependencies by using a professional tool for architecture visualisation. The output of this design iteration is the refined and empirically validated framework, designated as version 1.1, which is presented in Figure 4.3. This version constitutes a more robust, logically sound, and actionable blueprint for architecting health-focused Conversational Agents (CAs) to achieve specified health empowerment outcomes.

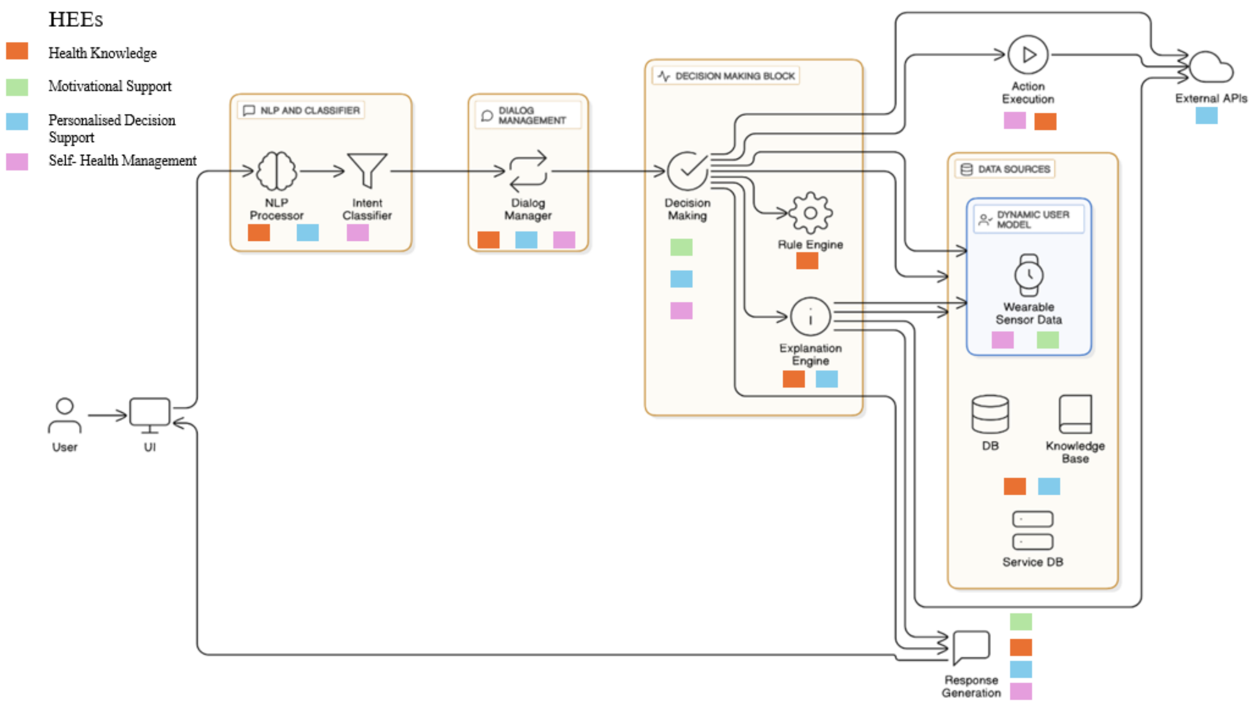


Figure 4.3: Functional Architectural Component to HEE Mapping Framework (V1.1)

4.2 Evaluation Phase of Artefact in DSRM

Recognizing evaluation as the crucial mechanism for determining an artifact's efficacy in Design Science Research (DSR), this section outlines the strategy for assessing the proposed framework. This process moves beyond the binary question of whether the artifact works to investigate how and why it functions, a depth of analysis essential for rigorous DSRM.

To operationalize this strategy, the evaluation targets specific design science outputs, including the framework as a design artifact and its embedded design theory (Sonnenberg & Brocke et al., 2012). This understanding leads to a set of critical assessment queries, consolidated in Table 4.4, which serve as a practical evaluation guide. These questions deliberately bridge core empowerment principles with concrete evaluation theories and metrics, creating a multi-faceted lens that encompasses technical (Ji et al., 2023; OWASP Foundation 2023), functional, and human-impact dimensions (Hibbard et al., 2005; Osborne et al., 2013). By synthesizing these methods from the literature, the Table 4.3 provides a comprehensive foundation for validating the framework's contribution and utility.

Table 4.3: Evaluation directions for framework

Evaluation Theories	Evaluation Criteria	Evaluation Objectives
Mapping-Integrity (Sonnenberg et al 2012)	Logical Consistency, Completeness (Components) Clarity of Definitions	• Does every CA component align with at least one empowerment element? • Is the mapping reproducible across experts?
CA-Component Performance (Ji et al., 2023), (OWASP Foundation 2023)	Actionability, Feasibility	• Does the component deliver the capability implied by the map? • Does the architectural component meet health-specific quality requirements?
Empowerment Outcomes (Hibbard et al., 2005, Osborne et al., 2013)	Utility, Efficacy	• Does the proposed CA framework measurably improve users' health knowledge, self-efficacy, and sense of autonomy?

1. **Establishing Mapping Integrity (Framework-Internal Validation):** The objective of internal validation within the framework is to assess the theoretical soundness and consistency of the framework itself. It addresses questions such as: Does every CA component align with at least one empowerment-focused element? Is the mapping logically consistent and reproducible across different domain

experts? This validation ensures the framework is coherent and well-structured before implementation (Sonnenberg et al 2012).

2. **CA-Component Performance (Technical Validation):** This evaluation theory verifies that each technical component functions as intended and meets the quality requirements of the healthcare domain. It answers the critical question: “Is the system technically robust, reliable, and safe enough for real-world health applications?”. This validation is a prerequisite for human-impact studies, as an inaccurate or unsafe system cannot be empowering, regardless of its theoretical design. Key performance indicators (KPIs) include dialogue success rates (Bickmore et al., 2011), natural language understanding (NLU) accuracy (Ji et al., 2023), dialog management component evaluation for handling varied and new dialog scenarios (Isa et al., 2024), critical safeguards against hallucination (Ji et al., 2023), and privacy breaches (OWASP Foundation 2023).
3. **Empowerment Outcomes (Human-Impact Validation):** The evaluation goal of this theory is to validate the framework's impact on the user. It moves beyond technical performance to answer the critical question: “Does using a CA built on the proposed framework actually make people feel more knowledgeable, competent, and in control of their health?”. Utilizing standardized, validated scales such as the Health Empowerment Scale (HES), Patient Activation Measure (PAM-13), and General Self-Efficacy Scale (GSES), this evaluation assesses whether interaction with a CA built on this framework leads to measurable improvements in users' knowledge, skills, confidence, and overall empowerment and have been referred as future research work (Hibbard et al., 2005; Osborne et al., 2013).

4.3 Evaluation with Experts: Framework (V1.1) Iteration

To ensure a comprehensive analysis of the expert feedback while maintaining transparency in the evaluation process, an individual expert rating analysis methodology was employed. This approach allowed for detailed examination of each expert's assessment patterns, background influences, and specific perspectives on the proposed framework. The evaluation criteria for V1.2 have been selected from the (Sonnenberg & vom Brocke, 2012) framework.

4.3.1 Data Collection and Preparation:

The data collection process involved administering the survey to experts via email and LinkedIn. To provide context for the evaluations, participants were asked to provide demographic information, including their professional position and years of experience (section A.1 in Appendix). The expert survey comprised two main sections: a quantitative part featuring a 5-point Likert scale to rate specific evaluation statements, and a qualitative part with open-ended questions to elicit detailed feedback. For analysis, the quantitative data were organized into a structured matrix where rows represented individual experts and columns represented their scores on each evaluation criterion, facilitating a clear overview of the responses (see Table 4.5).

4.3.2 Experts Survey Analysis for Framework V1.2:

The comprehensive evaluation of the proposed health empowerment CA mapping Framework was conducted through expert surveys (see Appendix) employing a 5-point Likert scale across ten distinct evaluation criteria. To ensure transparent reporting and enable detailed pattern analysis, Table 4.4 presents the complete rating profiles of all participating experts. The individual response matrix facilitates tracing specific feedback patterns, identifying potential background influences, and perspectives that informed the overall framework evaluation. This detailed approach aligns with established methodological practices for expert validation studies, ensuring both transparency in reporting and depth in analysis. To maintain analytical transparency and enable thorough examination of evaluation patterns, Table 4.4 documents the complete response set from all participating experts.

Table 4. 4: Expert survey analysis

Expert	**Title**	**Exp (Yrs)**	**C1**	**U1**	**C2**	**L1**	**C3**	**U2**	**A1**	**F1**	**F2**
E1	Head of AI	10 yrs	4	4	3	4	2	5	5	3	5
E2	Solution Architect	10+yrs	4	4	3	4	5	4	4	5	5
E3	Software Developer	7 yrs	4	5	4	5	5	5	4	5	5
E4	Sr. AI/ML Engineer	5 yrs	5	4	4	4	5	4	4	5	4
E5	Software Developer	5 yrs	5	5	5	5	4	4	4	5	5
E6	AI Developer	2 yrs	4	4	3	4	4	4	4	4	4
E7	Senior (NLP & Generative AI) Consultant	5 yrs	4	4	2	4	2	3	2	4	5

E8	NLP Research Assistant	3 yrs	5	5	4	5	5	5	5	5	5

The framework was evaluated by eight experts with diverse experience (2-10+ years) in software architecture, AI, and natural language processing. As shown in Table 4.6, the quantitative feedback indicated strong validation. The framework received high scores for its **Utility** (U1 Avg: **4.3**) and its ability to **bridge theory and practice** (U2 Avg: **4.3**). Experts were near-unanimous in recognizing its **high potential** (F2 Avg: **4.8**), affirming that the mapped components are technically capable of delivering empowerment functions.

However, the analysis revealed specific areas for improvement. The expanded dataset confirms and clarifies the initial findings. The criteria for **Completeness** (C2 Avg: **3.5**) now stands out as the lowest-rated aspect, indicating experts felt the framework could be more comprehensive. Furthermore, while **Clarity** (C1 Avg: **4.4**) remains solid, the lowest individual scores were given on **internal consistency** (C3), with two experts (E1 and E7) rating it a 2. This quantitative data strongly points to a need for refining the framework's structural cohesion and detail, which is elaborated in the qualitative feedback and has been considered in the V1.2 version framework.

4.3.2.1 Experts Feedback & Suggestions Analysis

The following Table 4.5 summarises the key themes identified from the experts' qualitative feedback. These themes, which are highlighted for emphasis, will be analyzed thematically in the subsequent section (See section 4.3.2.2).

Table 4.5: Expert qualitative survey feedback analysis

Expert	**Feedback & Comments**
E1	• **Develop a component** to fetch real-time data from the user's medication usage
E2	• The framework **would benefit** from **clear data flow** descriptions between modules (e.g., how NLP outputs feed into decision support and dynamic user modelling). Including examples or implementation patterns (like **API interaction or data persistence strategies**) would make it easier for architects to translate this into actual CA systems. Additionally, identifying scalability and integration considerations (e.g., how the CA might interface with third-party health APIs or EHR systems) would strengthen its real-world applicability

	Comments: The framework presents a solid conceptual mapping between technical components and empowerment principles. It's practical enough for early-stage CA architecture planning, especially in healthcare applications.
E3	• You **can add clear steps** on how the insights can be **applied in real-world health decisions** and also **ensure** the model **uses accurat**e and **consistent data** from **wearables** before making health suggestions.
E4	• A **key refinement** to enhance the rigor and practical relevance of the framework would be to incorporate a more **explicit representation of information flow** and inter-component dependencies. While the current mapping effectively aligns CA components with Health Empowerment Elements (HEEs), adding a detailed depiction of the sequential and iterative interactions, such as how user input propagates through NLP, classification, dialog management, decision support, and **personalization layers**, would make the architecture more actionable for system designers. Additionally, integrating considerations related to adaptive modelling, user profiling over time, and **safety/ethical constraints** would strengthen the framework's utility in real-world health contexts.
E5	• There could be some **elaborative components** in the **Dialogue Manager** (subcomponents may be) to clear the purpose and working in High level way of Dialogue manager. **Comments: Multimodal data** can be integrated to increase the knowledge base along with the wearable components.
E6	• **Develop explicit strategies** for **data management (security, privacy)** and personalization (user profiles, adaptive content), and specify how the CA integrates with external systems like wearable trackers
E7	• The flow can be enhanced by adding numerical indicators to show how many **distinct workflows** exist within the framework. Additionally, it should highlight the **components** that **interact** with each other using **double-sided arrows**, rather than single-sided ones, which currently suggest a one-way flow. **Comments: Adding examples of what kind of data each data source would house could increase the understandability of the framework.**
E8	• Does the data that's collected used in any analysis by health professionals? With regards to having a health knowledge expert, if the system also has **endpoint to the family doctor**, then that would be helpful

4.3.3 Qualitative Analysis and Thematic Synthesis

Theme 1: Enhanced Data Flow and System Dynamics

Experts E2 and E4 specifically highlighted the need for a clearer representation of information flow. E2 suggested "clear data flow descriptions between modules," while E4 and E7 recommended a "more explicit representation of information flow and inter-component dependencies." This indicates that while the static mapping of components to HEEs is logical, the dynamic, sequential interactions that bring the system to life are not fully captured. To incorporate this feedback, the new framework version V1.2 is presented with double arrows (see Figure 4.).

Theme 2: Expanded Components and Functionality

Experts requested a more detailed elaboration on specific components. E5 suggested breaking down the Dialogue Manager into "sub-components," and E1 proposed a new component to "fetch real-time data from the user's medication usage." This feedback calls for a more granular architecture that specifies sub-modules and integrates new data sources.

Theme 3: Strengthened Real-World Applicability and Safety

The experts emphasized practical implementation and safety concerns. E3 stressed the need for "clear steps on how the insights can be applied in real-world health decisions" and to "ensure the model uses accurate and consistent data." E4 mentioned integrating "safety/ethical constraints," and E2 pointed out the need for "scalability and integration considerations." This theme underscores the imperative to evolve the framework from a conceptual model to a practical, robust, and ethically sound design tool.

4.4 Post Evaluation Framework V1.2

Based on the expert feedback, the framework has been iteratively refined. The key enhancements in version V1.2 are as follows:

4.4.1. Introduction of Architecture Layers for Data Flow

To address Theme 1, data flow layers have been introduced. These layers show how NLP output triggers a database query, which then informs the Decision Support system, with health empowerment layers explicitly showing component interactions, and finally updates the User Model and leads to response generation. This makes the system's dynamics visually explicit and actionable for architects.

4.4.2. Components Expansion

To address Theme 2, several components have been expanded:

- External Data Resources Integration (Integration Layer): A new, dedicated component has been added to formally manage inputs from diverse sources, explicitly including E1's suggestion for "medication usage" and E5's idea of "Multimodal data," such as EHRs, patient-reported outcomes, and the previously included wearable sensors.
- Health Empowerment Layer: The Health Empowerment Layer is designed to actively support and motivate users in managing their health. It provides personalized recommendations through a dedicated Recommendation Engine, helping users make informed decisions tailored to their unique needs. The Goal Setting component enables users to define and manage health objectives via the Goal Management Module, while Progress Tracking offers real-time insights and visualizations through the Progress Dashboard. Additionally, the Educational Resources feature delivers accessible health education via the Health Education Module, empowering users with knowledge to improve their well-being.

4.4.3. Integration of Safety, Ethics Layer

To address Theme 3, a cross-cutting module that includes input validation, output safety checks (addressing E3's concern for accurate data), and ethical guideline compliance (addressing E4's concern). This refined version (see Figure 4.4), the Health Empowerment CA mapping Framework v2.0, directly incorporates the experts' feedback, transforming it into a more rigorous, actionable, and architecturally complete blueprint for building empowering health conversational agents. The refined version V1.2 has been designed by using a professional tool (https://www.eraser.io/ai/architecture-diagram-generator) as suggested by Expert 2 in the design & development phase of DSRM.

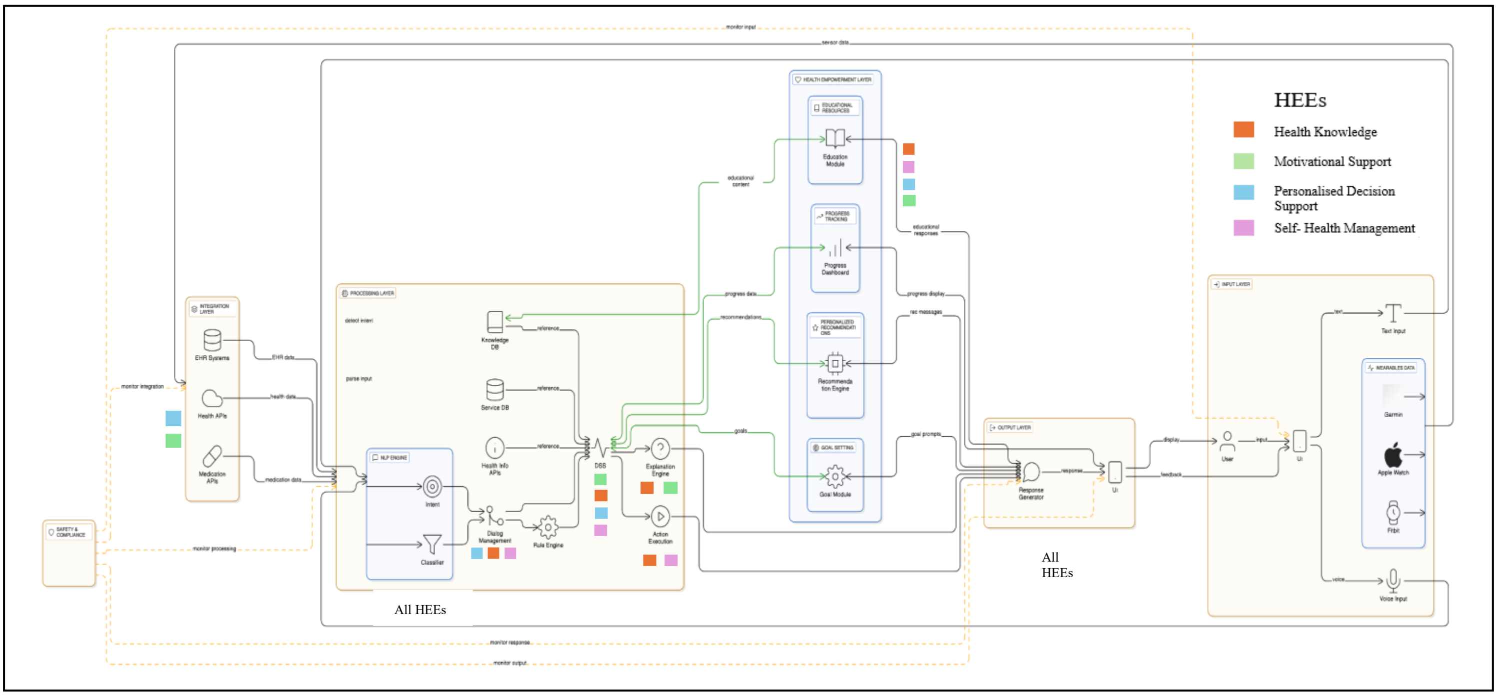


Figure 4.4: Functional Architectural Component to HEE Mapping Framework (V1.2)

Access this architecture at the following link for a better view: https://drive.google.com/file/d/1cI4YX2Tqx-1MRfyYZSc1ONvO1ppD7ex7/view?usp=drive_link

4.5 Expert Survey Results

To show the evaluation by experts, the following comparison table (see Table 4.6) has been developed. The table shows the comparison between the different iterations of the CA health empowerment mapping framework. The comparative analysis validates the iterative design science approach of this research. Each version of the framework was informed by rigorous evaluation: v1.0 by the synthesis of literature, and v1.1 by structured expert validation. The incorporation of critical feedback into v1.2 has resulted in a more **robust, complete, and actionable** framework. It not only maintains the core strength of linking CA components to health empowerment elements but also provides a structured methodology for implementing these components safely and effectively in real-world health contexts. This evolution underscores the framework's increased rigor and its enhanced potential to guide the development of truly empowering health conversational agents.

Table 4.6: Mapping Framework Evaluation Results

Evaluation Criteria	Initial Framework V1.0	V1.1 (Post Design & Development Phase Iteration)	V1.2 (Post Expert Validation)
Clarity & Understandability	Static mapping of CA components to HEEs. A foundational "what maps to what" model	Refined component definitions & consolidated HEE links. Improved theoretical grounding.	**Dynamic system design**; Adds data flow, safety, and real-world integration.
Completeness	Covered basic components but missed relationships and real-world concerns	Improved theoretical coverage but lacked implementation details	**Comprehensive coverage** including safety, integration, dynamics, and practical deployment concerns
Logic & Consistency	Flat list of components; relationships and dependencies implied but not explicit.	Categorization of components begins; logical grouping emerges.	**Layered Architecture** (Input, Core, Health Empowerment Layer, Output) with a Safety & Ethics Layer.
Utility & Actionability	Conceptual blueprint; useful for understanding but limited guidance for implementation.	More precise mapping offers better design direction.	Explicit data flows & granular sub-components (e.g., Explanation Subsystem) provide direct architectural guidance
Feasibility	Covers core technical-empowerment mapping.	Strengthens the theoretical bridge.	Addresses critical gaps: Data flow, Safety/Ethics, and Real-world APIs

4.6 High level Data Flow Design

Figure 4.4 presents the static architecture of the proposed HCA Empowerment Framework, illustrating the core components and their relationships. Building upon this static view, **Figure 4.5** traces the **dynamic data**

flow through these components during a typical user interaction cycle, from input to response and feedback learning. The flow is organised into **six sequential steps**, from user input to response generation and feedback learning.

Step 1: User Input and Data Collection

The process begins at the **User Interface**, which receives three types of input user Input (text or voice), **user feedback**, physiological data from wearable sensors (e.g., heart rate, steps, glucose levels).

Step 2: Natural Language Processing

The raw user input is sent to the **NLP/NLU Module**, which extracts intent (what the user wants to do), entities (key information within the message). The parsed intent and entities are then forwarded to the **Decision Support System**. Simultaneously, the User ID is sent to the **Dynamic User Model** to retrieve the user's existing profile.

Step 3: User Profile Retrieval

The **Dynamic User Model** retrieves the user's stored information from the user database, including profile (demographics, fitness level), history (past interactions, health logs), preferences (notification settings, goals). This user state data is then passed to the **Decision Support System** to inform personalisation.

Step 4: Knowledge and Rule Processing

The **Decision Support System** gathers additional context from three sources: **Knowledge Base** - provides medical facts and health guidelines. **Rule Engine** - applies IF-THEN trigger rules based on user data. **External APIs / EHR** - retrieves external data (e.g., electronic health records, pharmacy information).

Step 5: Recommendation and Empowerment Output

Using all collected inputs, the **Decision Support System** generates a personalised recommendation. This recommendation is then sent to two parallel components such as **explanation engine** - produces a **justification** explaining why the recommendation was made (supporting user Autonomy). **Motivational support** - generates encouragement and reinforces the user's competence (supporting Competence and Relatedness). Both outputs - the justification and the encouragement - are sent to the **Response Generator**. The **Response Generator** assembles the final message and sends it back to the **User Interface** for display to the user.

Step 6: Feedback and Model Updating

The user provides feedback via the User Interface. This feedback signal is sent to the **Dynamic User Model**, which updates the user's profile in the User Database. This continuous learning loop enables the system to become more personalised and effective over time.

For better view, please zoom in the figure below.

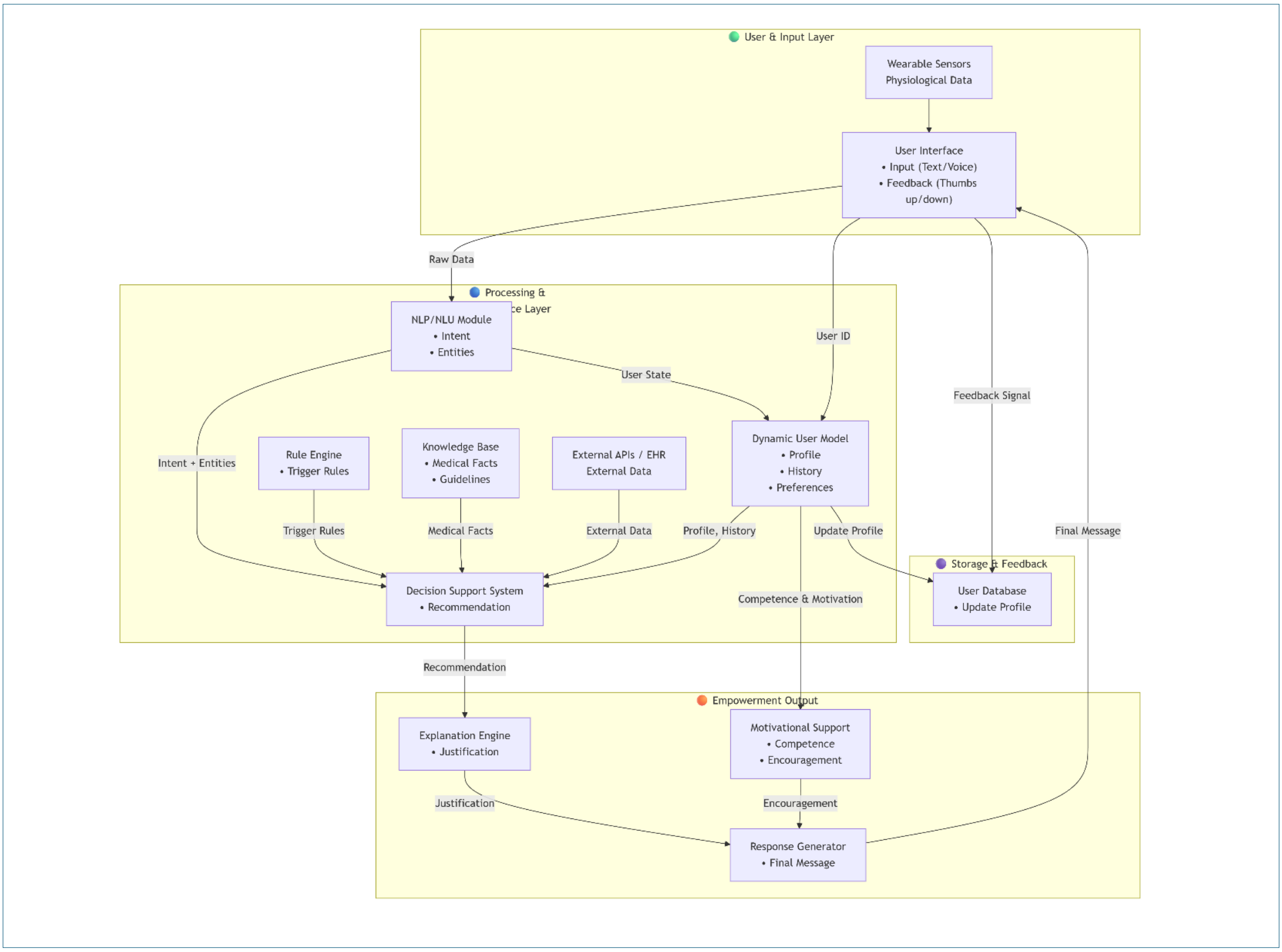


Figure 4.5: High Level Data Flow Diagram of HCA Architectural Framework

4.7 Prototype Design Demonstration

This prototype serves as a **proof-of-concept instantiation**, demonstrating that the abstract framework is technically realizable and that its core components such as the Dynamic User Model, Explanation Engine, and Motivational Support can be operationalized in a working system. In Design Science Research, evaluation can take multiple forms depending on the maturity of the artifact and the research context (Venable et al., 2016). Sonnenberg and vom Brocke (2012) explicitly include 'expert evaluation' and 'technical prototype evaluation' as valid patterns within DSRM, particularly when the goal is to establish the artifact's feasibility and design quality prior to large-scale empirical testing. The current study follows this pattern: expert evaluation of the mapping framework (v1.0 to v1.2), complemented by a prototype demonstration and evaluation to provide empirical evidence.

Prototype design can be access at this link: https://harp-rouge-46369429.figma.site/

4.7.1 Sign- Up Experience

The prototype instantiation of the proposed HCA Empowerment Framework is organized around four core user empowerment functions: **Understand, Decide, Motivation, and Manage**. These functions directly operationalize the Health Empowerment Elements (HEEs) Autonomy, Competence, and Relatedness within the conversational agent's interaction flow. The following subsections present screenshots and explanations of how the prototype supports each function.

The prototype begins with a **sign-up or sign-in screen**, where users authenticate using an email address and password. Upon successful authentication, the user is redirected to the **Understand screen** the first of four core empowerment functions described below. The prototype also includes an **Account screen**, which displays the user's name and self-reported fitness level. From this screen, users can access a **Settings tab** that contains three configurable options: **Notifications** (enable/disable reminders and alerts), **Privacy** (manage data sharing preferences), and **Connected Devices** (view and manage wearable or health device integrations). The Account screen further provides a **health data summary** (e.g., recent step counts, blood pressure readings, or glucose levels) aggregated from connected devices and user inputs, as well as a **Logout** button to end the session securely. This account and settings infrastructure support the Dynamic User Model by capturing baseline user attributes and preferences, which in turn enables personalisation across all four empowerment functions. (see Fig 4.6)

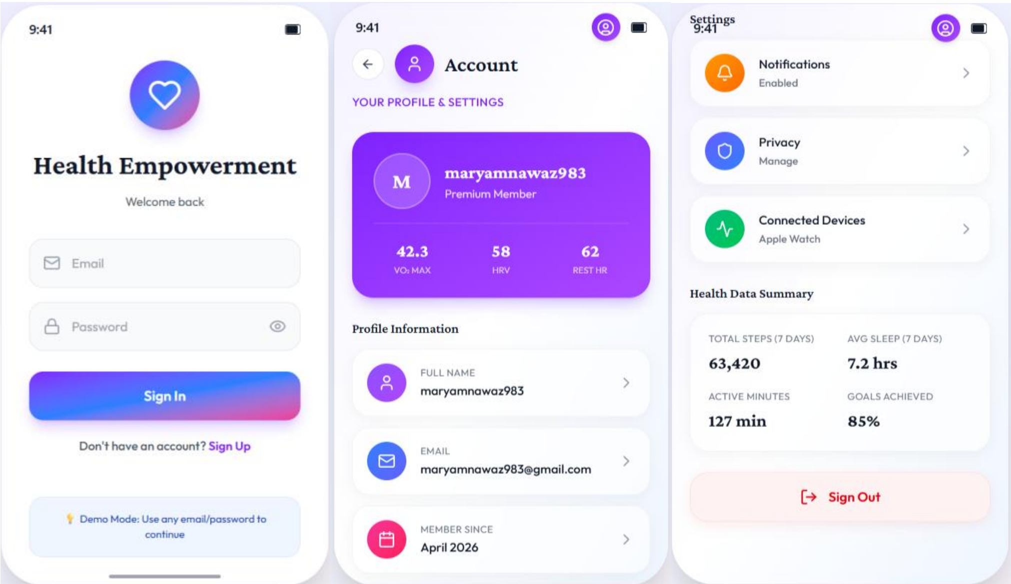


Figure 4.6: Sign In/Up and Account Management & Health Data Summary

4.7.2 Understand: Building Health Literacy and Awareness

The **Understand** tab corresponds to the user's need to acquire accurate, accessible health information. It is primarily supported by the **Knowledge Base** and the **Explanation Engine**. When a user asks a question (e.g., "Show my biometrics or Blood pressure explained?"), the prototype retrieves relevant, evidence-based information and presents it in clear, non-technical language from referenced resources. The Explanation Engine also provides contextual justifications for why certain information is important, directly fostering **Competence** by enhancing the user's health literacy. Following prototype screen showing a user asking a health question (health metrics, and another question blood pressure explained) and receiving a clear, explained answer.

Example: user click on biometrics tab and asks, *"how my biometrics from today's health data?" and the agent responds with a short, educational, visualised and comprehensive biometrics from linked wearable (see Fig 4.6a). Furthermore, if user want to know about the medical terms like HRV (Heart Rate Variability), on asking the CA is giving the information about the requested terms (see Fig 4.6b).*

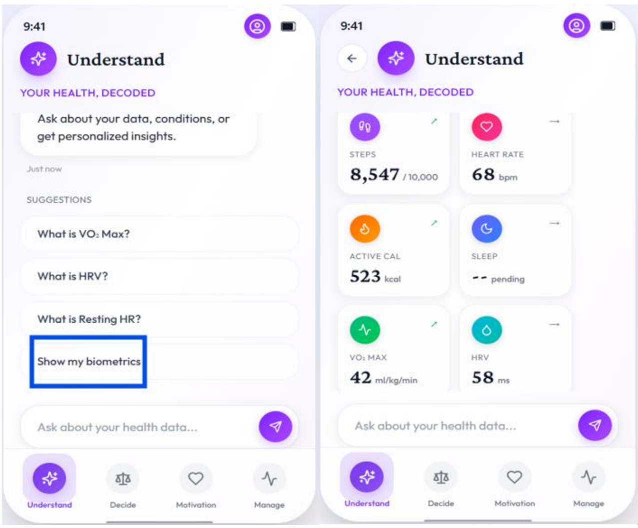


Figure 4.6a: Understand Screen - Building Health Literacy through Knowledge Retrieval and Explanation

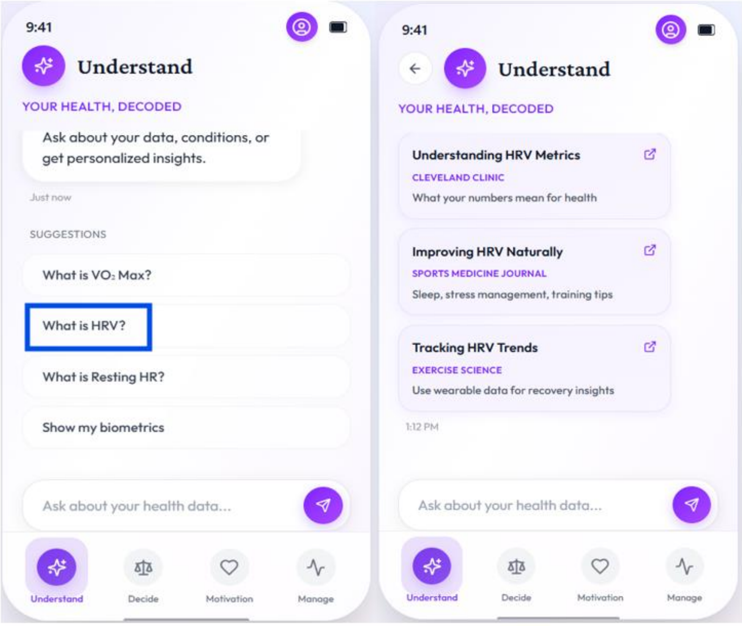


Figure 4.6b: Understand Screen - Building Health Literacy through Knowledge Retrieval and Explanation

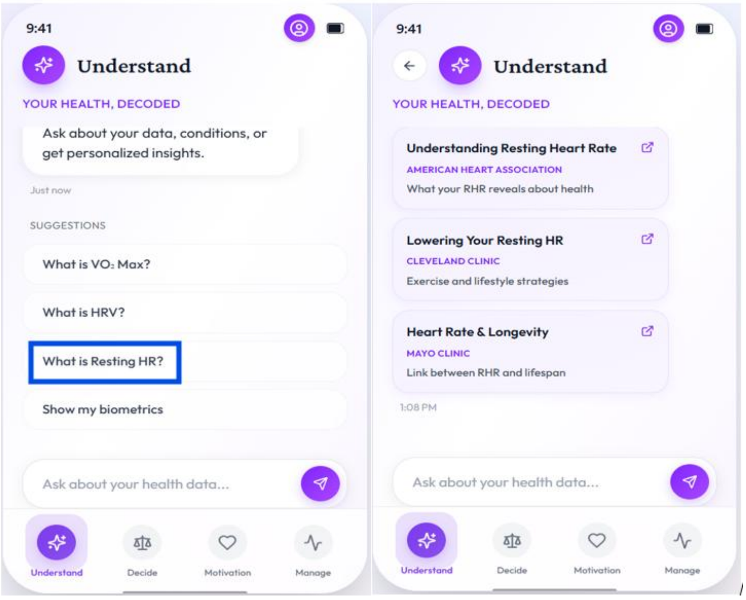


Figure 4.6c: Understand Screen - Building Health Literacy through Knowledge Retrieval and Explanation

4.7.3 Decide: Supporting Informed, Autonomous Choices

The **Decide** function addresses the user's need to make informed, self-endorsed health decisions. This function is powered by the **Decision Support System (DSS)**, the **Rule Engine**, and the **Dynamic User Model**. The prototype presents personalized recommendations (e.g., "Based on recent activity what's best for my fitness level?") and clearly explains the reasoning behind each suggestion. This transparency supports **Autonomy**, as the user understands the rationale and retains the final choice. *Following prototype screen offering a personalized recommendation with a visible explanation (e.g., a collapsible "Why this suggestion?" section) (see Fig 4.7).*

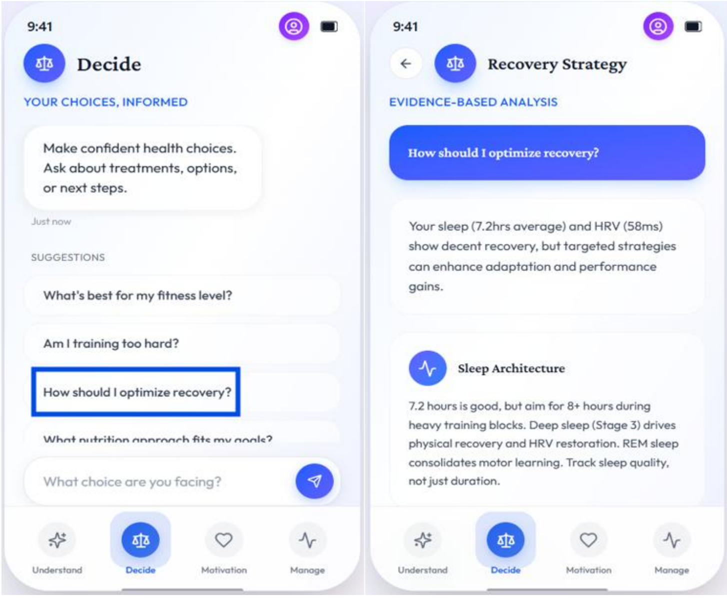


Figure 4.7a: Decide screen – Supporting Informed, Autonomous Health Decisions

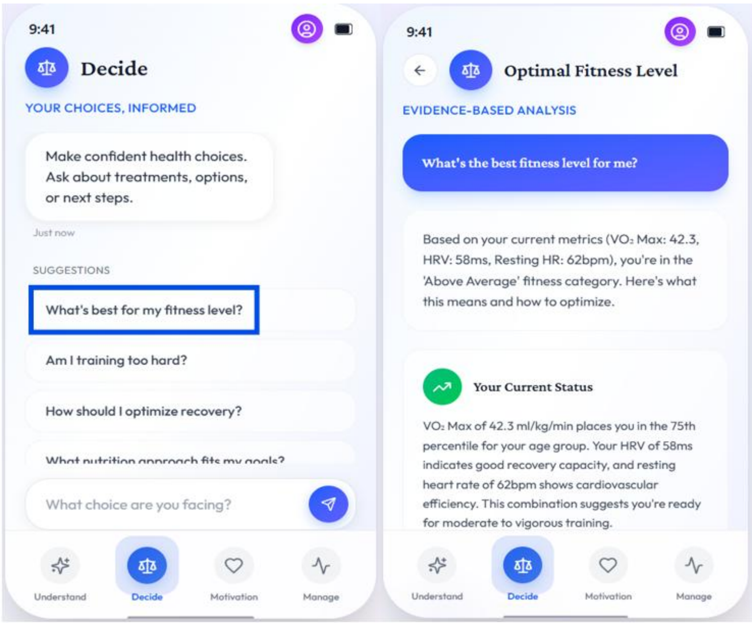


Figure 4.7b: Decide screen – Supporting Informed, Autonomous Health Decisions

4.7.4 Motivation: Sustaining Engagement and Self-Efficacy

The **Motivation** function is designed to maintain user engagement and build confidence over time. It is implemented by the **Motivational Support Engine**, which delivers tailored encouragement, goal reminders, and positive reinforcement based on the user's progress and preferences stored in the Dynamic User Model. For example, after a user completes a logged health action, the prototype responds with a competence-affirming message: "Great job! you're building a healthy habit!" This directly supports **Competence** and fosters a sense of **Relatedness** by acknowledging the user's efforts.

Following prototype screen shows motivational message, ideally shown after a user action (e.g., logging a meal, completing a step goal). (see Fig 4.8)

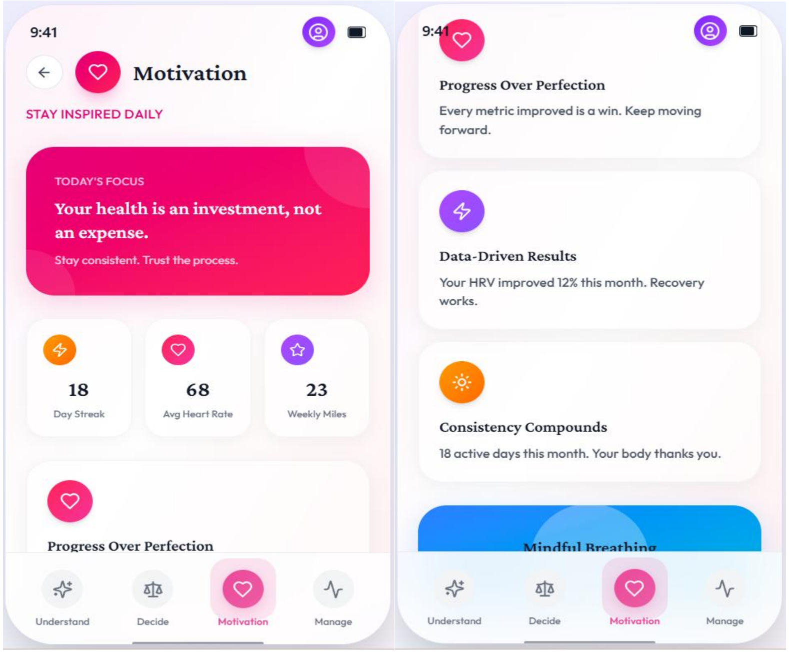


Figure 4.8: Motivation Screen – Delivering Tailored Encouragement and Positive Reinforcement

4.7.5 Manage: Enabling Proactive Health Self-Management

The **Manage** function equips the user to track, monitor, and adjust their health behaviours over time. This function integrates the **Dynamic User Model**, **Rule Engine**, and **Data Storage** to provide dashboards, progress visualizations, and automated alerts. For instance, the prototype is displaying weekly biometrics or remind a user to refill a prescription based on a rule trigger. By giving users, a clear view of their health trajectory and actionable tasks, the Manage function reinforces **Competence** (seeing progress) and **Autonomy** (deciding what to track and when to act).

Following *prototype's manage dashboard: e.g., a progress chart showing step counts over the past week, a list of pending health tasks (medication reminders, upcoming appointments), or a simple "Your Health Summary" panel. (see Fig 4.9)*

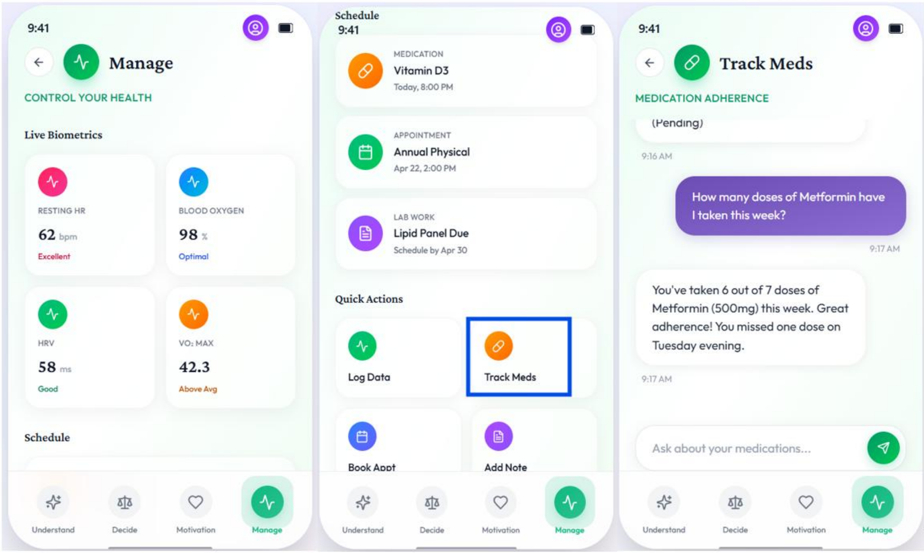


Figure 4.9: Manage Screen – Enabling Proactive Health Tracking and Self-Management

4.8 Prototype Design Evaluation

4.8.1 Survey Administration and Participant Demographics

The prototype evaluation survey was administered online via Microsoft Forms to **eHealth Software designers, developers** and **researchers**. A total of **13** evaluators participated in the study. Participants were provided with a link to the functional HECA prototype and instructed to navigate through all key screens Sign-In, Understand, Decide, Manage, Motivation, and Account before completing the survey. The survey consisted of Likert-scale questions (rated 1 = Strongly Disagree to 5 = Strongly Agree) organised into four sections: General Usability (adapted from Patient Satisfaction & Usability with Apps and mHealth App Usability Questionnaire) (Bruni et al 2025), Empowerment Screen Evaluation (four subsections corresponding to Understand, Decide, Manage, and Motivation), and Interface/User Experience.

4.8.2 Quantitative Data Analysis

Responses were automatically collected in a Microsoft Form https://drive.google.com/drive/u/1/folders/1zeJ6axI1FVTZgtta7zdTP0nChQtVvbjg and exported to Microsoft Excel for statistical analysis https://docs.google.com/spreadsheets/d/1FP3r4zJsToB2qln5r7lpdONKVFwNWsJT/edit?gid=480272381#gid=480272381.

For each survey section, the **mean** (average) and **standard deviation (SD)** were calculated. The mean provides the central tendency of responses, indicating the average level of agreement with each statement. The standard deviation measures the dispersion of responses around the mean; a **lower SD** indicates **greater consensus** among evaluators, while a **higher SD** suggests more **varied opinions** (Brown, 2019). Screen-level means were then computed by averaging the scores of all questions belonging to each empowerment screen (Understand, Decide, Manage, Motivation). Overall **usability** was calculated as the **mean** of all questions. The results, summarised in Fig 4.10 and interpretation in Table 4.7, indicate that the prototype demonstrates **good overall usability** (mean = 4.1/5, SD = 1.1) and successfully operationalises the four Health Empowerment Elements, albeit with some variability in responses.

Figure 4.10 presents the mean evaluation scores for each of the six evaluation foci based on the survey responses of 13 evaluators. Evaluators particularly appreciated the quick loading of responses (mean = 4.2/5, SD = 0.9) and the ease of navigation (mean = 4.1/5, SD = 1.0). However, the visual clarity of the interface showed higher variability (mean = 4.0/5, SD = 1.2), with one evaluator rating this aspect as "Strongly Disagree." This outlier suggests that while most users found the interface clear, improvements in layout consistency may benefit users with different visual preferences.

The **Understand screen** received a mean score of 4.0/5 (SD = 1.0). Evaluators found the answers easy to understand (mean = 4.1/5, SD = 1.1) and agreed that the screen would help users feel more knowledgeable about their health (mean = 4.0/5, SD = 0.9). However, question ("The explanations help me learn why something is important") received a lower mean of 3.8/5 (SD = 1.0). This suggests that while the answers are clear, the depth of explanatory reasoning could be enhanced to better support user Competence.

The **Decide screen** scored 4.0/5 overall (SD = 1.0). The transparency of the "Why this suggestion?" justification was rated positively (mean = 4.1/5, SD = 0.9), confirming that the Explanation Engine effectively supports user Autonomy by making the system's reasoning clear. However, the personalisation of recommendations received a lower score (mean = 3.8/5, SD = 1.1), indicating that some evaluators perceived recommendations as generic. This suggests that the Dynamic User Model's personalisation capabilities require refinement to better tailor suggestions to individual user contexts.

The **Motivation screen** received the lowest mean score among the four screens (mean = 3.8/5, SD = 1.4). Notably, this screen also showed the highest standard deviation, indicating substantial variability in evaluator opinions. One evaluator rated the motivational messages as "Strongly Disagree" for authenticity, while others rated them as "Strongly Agree." The authenticity of motivational messages (Q10) received the lowest individual question score (mean = 3.7/5, SD = 1.5). This finding suggests that the Motivational Support Engine requires further refinement to ensure consistent, authentic, and varied encouragement across different user expectations. The acknowledgment of user progress (Q11) scored slightly higher (mean = 3.9/5, SD = 1.3), indicating that the content is valued when it resonates with the user.

The **Manage screen** received a mean score of 4.1/5 (SD = 1.0). Evaluators found the health data summary particularly clear and useful (mean = 4.2/5, SD = 0.9). User control over health tasks received a slightly lower score (mean = 3.9/5, SD = 1.1), indicating that while data presentation is effective, the sense of user agency in task management could be further strengthened through more interactive controls and customisation options.

The **Interface** and **User Experience** received the highest ratings overall (mean = 4.2/5, SD = 1.1). The logical transition between screens (Understand → Decide → Manage → Motivation) was particularly well-received (mean = 4.3/5, SD = 0.9), confirming that the prototype's navigation structure is intuitive and supports the intended user journey.

All statistical calculations were performed using Microsoft Excel for Windows. The complete dataset, including individual evaluator responses and Microsoft summary links, are provided in above section and Appendix A.2.

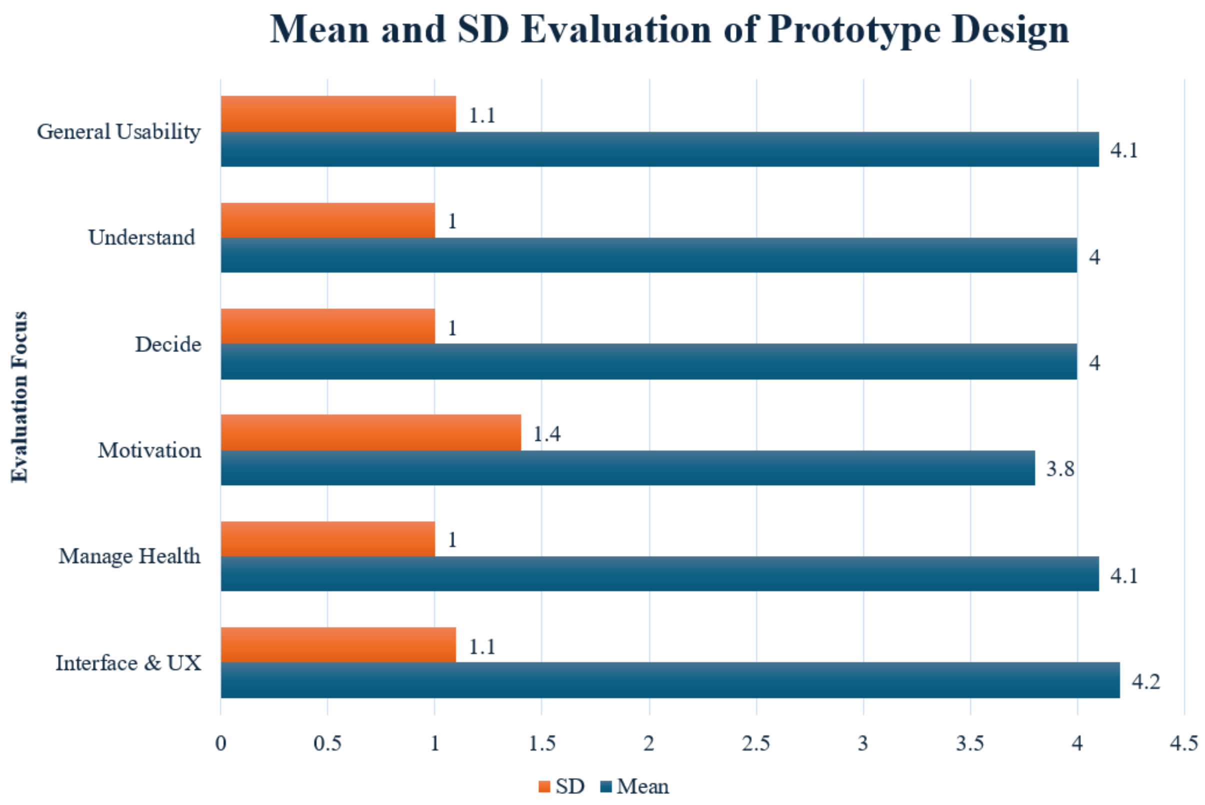


Figure 4.10: Mean Evaluation Scores by Empowerment Screen

Table 4.7 summarises the interpretation of the prototype evaluation results. The prototype demonstrates good overall usability (mean = 4.1/5) and strong interface design (mean = 4.2/5). The Understand, Decide, and Manage screens scored between 4.0 and 4.1, indicating good support for Competence and Autonomy, though personalisation of recommendations requires improvement. The Motivation Screen received the lowest score (mean = 3.8/5) and highest variability (SD = 1.4), identifying the Motivational Support Engine as the primary area for refinement. Overall, the prototype is usable and aligned with the theoretical framework, with clear directions for targeted improvement in the next iteration.

Table 4.7: Prototype Design Evaluation Results

Evaluation focus	**Interpretation**
General Usability	Good overall usability

Understand Screen (Competence)	Good support, clear answers
Decide Screen (Autonomy)	Good transparency: personalization needs improvements
Motivation Screen (Relatedness)	Moderate support; highest variability
Manage Screen (Self-Management)	Good support; clear data summary
Interface & UX	Strong design; logical navigation
Overall Prototype Score	Prototype is useable and aligned with framework

4.9 Conclusions:

This chapter presented a comprehensive design & development, and evaluation phase of (DSRM phases) for the Health Empowerment CA mapping Framework through a rigorous expert survey. The quantitative results demonstrated strong endorsement of the framework's core value, with high scores for its **utility** (U1=4.3), its ability to **bridge theory and practice** (U2=4.3), and its overall **potential** (F2=4.8). The qualitative analysis, however, provided critical depth, identifying three key themes for refinement: the need for explicit data flow dynamics, enhanced component granularity, and the integration of safety and real-world applicability.

In direct response to this feedback, the chapter introduced the refined Health Empowerment CA mapping Framework V1.2 (see Figure 4.4). This evolved version features a layered architecture clarifying system boundaries, explicit data flows between components, a safety and ethics layer, and granular sub-components that enhance its actionability for software architects. This iterative process, moving from v1.0 to v1.2, demonstrates a systematic and evidence-based approach to framework development. The findings not only validate the framework's initial conceptual soundness but, more importantly, transform it into a more robust, complete, and practical tool, thereby effectively addressing the research aim of creating a validated blueprint for designing empowerment-focused health CAs.

The prototype screens presented above demonstrate that the proposed HCA Empowerment Framework is not merely a theoretical abstraction but a technically realizable artifact. Each of the four empowerment elements, **Understand, Decide, Motivation, and Manage** has been instantiated through the framework's core architectural components: the Knowledge Base and Explanation Engine for Understand; the Decision Support System, Rule Engine, and Dynamic User Model for Decide; the Motivational Support Engine for Motivation; and the Dynamic User Model with integrated data storage for Manage. The account and settings infrastructure further operationalize the Dynamic User Model by capturing user attributes, preferences, and connected device data, enabling the personalisation that underpins all four functions.

While the expert validation of the mapping framework (v1.0 and v1.2) established theoretical and construct validity, the prototype provides evidence of **technical feasibility and implementation fidelity**. The prototype successfully translates abstract component-to-HEE mappings into concrete, screen-level interactions that a user can experience. The evaluation results demonstrate that the prototype successfully instantiates the proposed mapping framework. The Understand, Decide, Manage, and Motivation screens each received mean usability scores above 4.1/5, with the Explanation Engine and Motivational Support Engine being particularly well-received. The Manage screen was identified as an area requiring refinement, specifically regarding the visual presentation of progress tracking. These findings provide actionable directions for the next iteration of the prototype (v1.2).

In summary, the prototype fulfils its intended role within the **Design and Development** phase of DSRM. It demonstrates that the theoretical mapping framework (v1.2) can be successfully instantiated into a functional prototype, it surfaces specific refinements for future iterations, and it provides a concrete foundation for the next stage of evaluation. The evaluation conducted in this chapter comprising expert review of the framework and UI & UX designers &Health App developers and Researchers based usability testing of the prototype addresses validity of the proposed artifact, in accordance with DSRM guidelines (Venable et al., 2016; Sonnenberg & vom Brocke, 2012).

Chapter 5: Conclusions and Future Research Directions

This chapter concludes the proposed research and discusses the contributions and further directions. A systematic mapping framework for CA architectural components and health empowerment elements has been proposed as an output of this research. To design the proposed mapping framework, this research employs the method of standardising HEEs and the relationship between these HEEs and CA architectural components (see Chapters 2, 4). Furthermore, the limitations of this research are discussed to clarify its scope and highlight the insufficiencies of this research. In view of these limitations, research directions are analysed and articulated to enhance this research in the future.

5.1 Summary

This research is guided by the DSRM under six phases to systematically identify the problem, determine objectives, design & develop, and evaluate theories and metrics for the artefact proposed in this research. Firstly, the method proposed standardised health empowerment elements (HEEs) and the representation of these HEEs in relation to CA architectural components and their description, which has been extracted from the literature.

To follow the DSRM, this research dives into the design and development phase (see Chapter 4). Furthermore, this research highlights the last step of DSRM, such as various evaluation theories and metrics with experts' validation to evaluate the proposed framework in terms of a prototype for individuals' participation in their health. Lastly, the demonstrations and communication phase have been presented. The details and methods (see Chapters 2, 3 and 4) to propose this research with contributions have been articulated in the below mentioned sections.

5.2 Main Research Contributions

Regarding contributions, this research is aligned with the research questions. In the first three chapters, the MRQ and three SRQs are identified by investigating current situations and issues in this domain based on the literature. The Design Science Research Methodology (DSRM) was adopted to provide a systematic approach for addressing these questions. Consequently, Chapters 2, 3, and 4 investigate and answer the sub-research questions through the following contributions: the standardization of Health Empowerment Elements (HEEs); the development of a component-to-HEE mapping framework; the evaluation of this framework via expert review; and the presentation of a functional prototype instantiated from the evaluated framework. Chapter 5 provides details on the contribution in terms of SRQs and future directions, with limitations of this research. The main contributions and outputs are summarised and listed from both academic and industrial sides.

5.2.1 Academic Contributions

For MRQ: This study has developed and empirically validated a novel framework that systematically maps (HEEs) to CA architectural components. Expert validation confirmed the framework's high utility (mean rating: 4.3/5) and strong potential for practical implementation (mean rating: 4.8/5), providing healthcare researchers and practitioners with an evidence-based tool for designing CAs that actively promote health empowerment. The validated framework serves as a crucial bridge between empowerment theory and technical implementation with empirically evaluated prototype design. It demonstrates how empowerment concepts are translated into concrete system components, enabling the operationalization of theoretical constructs such as autonomy and self-management through specific technical capabilities in NLP, dialogue management, and decision support systems.

For SQR1: Through literature analysis, this research has synthesized a comprehensive model of HEEs that specifically addresses previously underrepresented dimensions. The findings reveal that critical elements, such as emotional support and proactive health management, have been notably neglected in existing CA designs, providing important guidance for future research focus. This research has generated and validated an empirically derived taxonomy of CA architectural components specifically relevant to healthcare applications. Expert feedback confirmed the completeness and logical connectivity of these components, addressing the previously fragmented understanding of health CA architecture.

For SQR2: This research develops and validates clear functional relationships between CA components and empowerment outcomes. The expert-confirmed mappings explain *how* technical capabilities enable empowerment, for instance, demonstrating how a Dynamic User Model facilitates self-management through continuous personalization, and how an Explanation Subsystem supports informed decision-making by making system reasoning transparent to users.

5.2.3 Industrial Contributions

- **For Standardized Empowerment Taxonomy:** Provides a standardized taxonomy for defining and implementing health empowerment elements (HEEs), offering a consistent framework for industry practitioners (See Figure 2.1 in Chapter 2).
- **For the Architectural Component Mapping Framework:** Establishes a clear mapping between CA architectural components and health empowerment elements, enabling holistic design approaches that integrate technical and empowerment considerations (See Sections 4.2, 4.3 in Chapter 4.
- **A Validated Framework for Empowerment-Focused CA Design:** Delivers a reusable health empowerment-focused architecture that reduces development time and serves as a reference standard for implementing empowerment features in conversational agents and other digital health interventions to health tech companies (See Figure 4.3 in Chapter 4).

- **A Prototype Design for Implementation:** Provides a prototype design that can be adopted for future implementations to measure tangible user outcomes in everyday health and wellbeing (Section 4.7 in Chapter 4).

5.3 Limitations and Challenges

This research, while providing a foundational contribution, is subject to several limitations that should be considered when interpreting its findings and scope. These are categorized as limitations referring to RQs, methodological, domain-specific, and general limitations. The details are presented below:

5.3.1 Limitations referring to SRQs

For MRQ: The limitations of this research are organized according to the Main Research Question (MRQ) and Sub-Research Questions (SRQs), addressing constraints in methodology, scope, and evaluation:

- Due to time constraints, this study did not include extensive empirical data collection to validate the perceived health empowerment outcomes from individuals of the proposed framework. The contributions are primarily conceptual and design-oriented, requiring future implementation testing to assess real-world effectiveness.
- The HEEs identification methodology, while systematic, may have overlooked certain empowerment aspects due to terminology variations in the literature. While the identification of HEEs employed a rigorous process of standardizing diverse terminologies into a unified framework, the very nature of conceptual fragmentation in the literature presents a challenge. Research methodology specifically catered to this issue by grouping synonymous constructs (e.g., "self-efficacy," "perceived competence") under standardized HEEs. However, it remains a theoretical possibility that an empowerment aspect was consistently described with a unique, non-synonymous term that our search and synthesis process did not capture.
- The systematic literature review methodology, including search strings and publication period limitations, may have affected the comprehensiveness of identified CA architectural components. This potentially limited the framework's scope to components predominantly represented in the available literature.

An initial expert survey was conducted to validate the framework's components and mappings; however, the generalizability of its findings is limited by a small sample size. While this provides preliminary, qualitative insights, the restricted number of participants may reduce the broader applicability of the validation. Consequently, these methodological boundaries define the status of the framework and underscore the necessity for more extensive empirical studies to robustly confirm the efficacy of the proposed component-HEE relationships in operational systems.

Beyond methodological constraints, this research is also subject to limitations inherent to the interdisciplinary domain of digital health and conversational agents. These limitations concern the application of the theoretical framework across diverse practical contexts. The conceptual understanding of "health empowerment" may vary across medical disciplines and cultural contexts, and it continues to evolve. The proposed taxonomy may not fully capture its dynamic and context-dependent nature. The framework focuses on architectural design principles but does not address potential technical barriers to implementation, such as data integration challenges, interoperability issues with health record systems, or computational resource requirements. The HEEs and mappings were developed to be general but may require adaptation or specialisation when applied to specific health conditions (e.g., chronic disease management vs. mental health support).

5.4 Future Work and Research Directions

This research was driven by the need to translate the theoretical concept of health empowerment into practical architectural guidelines for conversational agents (CAs). The iterative development and validation of the Health Empowerment CA Mapping Framework have yielded several key empirical findings:

The expert-validated framework demonstrates that health empowerment is not achieved through a single component but through the interconnectivity of a system. For instance, "Personalized Decision Support" requires the functional integration of the NLP engine (to understand user context), the Knowledge Base (to provide evidence), the User Model (to tailor information), and the Explanation Subsystem (to build trust). This finding moves the field beyond simply adding an educational module and towards a holistic, system-level design philosophy.

The research identified that while CAs are often strong in information delivery, they frequently lack the architectural components for sustained empowerment. Experts confirmed the critical importance of, yet general absence of, dedicated components for longitudinal user modelling (for adaptive self-management support) and a formal safety and ethics layer (to ensure reliable and trustworthy interactions). This gap analysis, derived from both literature and expert consensus, provides a clear research and development agenda. The expert validation survey strongly confirmed that the Health Empowerment CA Mapping Framework fulfils a need in the research community. The high ratings for Utility (4.3/5) and Potential (4.8/5) indicate and mean of General Usability of prototype (mean = 4.1/5, SD = 1.1) shows that the framework is not just an academic exercise but is perceived as a valuable tool for structuring and communicating the design of complex health CAs, effectively bridging the theory-practice divide.

This research has several key directions for future work. For instance, the logical next step is to implement the mapping framework in a functional CA prototype (see chapter 4) targeting a specific health domain, such as diabetes management or anxiety support. This would allow for longitudinal studies to measure the causal impact of specific architectural choices on empowerment outcomes (e.g., using scales based on psychological empowerment theory). This addresses the "how effectively" question raised in research findings. While the HEEs are grounded in literature and validated by technical experts, conducting interviews and focus groups would enrich the taxonomy with lived experiences, as done in user-centred design studies like (Bickmore et al., 2018), ensuring real-world empowerment needs. Moreover, research is needed to investigate how the health empowerment CA mapping framework must be adapted for different cultural contexts, health literacies, and clinical domains. This explores the **generalizability** of the framework and would lead to a more nuanced understanding of how empowerment is context dependent.

References

1. Abdulrahman, A., & Richards, D. (2019). Modelling Therapeutic Alliance using a User-aware Explainable Embodied Conversational Agent to Promote Treatment Adherence. https://doi.org/10.1145/3308532.3329413
2. Alghamdi, M. S., Alhussain, Dr. A. A., & Baker, Dr. O. G. (2022). Empowerment in the Healthcare Context: Concept Analysis. Saudi Journal of Nursing and Health Care, 5(9), 176–181. https://doi.org/10.36348/sjnhc.2022.v05i09.001
3. AlQudah, A. A., Al-Emran, M., & Shaalan, K. (2021). Technology Acceptance in Healthcare: A Systematic Review. Applied Sciences, 11(22), 10537. https://doi.org/10.3390/app112210537
4. Andri Färber, Spindler, A. de, Moser, A., & Schwabe, G. (2023). Closing the Loop for Patients with Chronic Diseases - from Problems to a Solution Architecture. Zurich Open Repository and Archive (University of Zurich), 361–370. https://doi.org/10.1109/ichi57859.2023.00055
5. Angelini, L., Mira El Kamali, Mugellini, E., Omar Abou Khaled, Röcke, C., Porcelli, S., Mastropietro, A., Rizzo, G., Boqué, N., Maria, Palumbo, F., Girolami, M., Crivello, A., Canan Ziylan, Subías-Beltrán, P., Orte, S., Carlo Emilio Standoli, Laura Fernandez Maldonado, Maurizio Caon, & Sykora, M. (2022). The NESTORE e-Coach: Designing a Multi-Domain Pathway to Well-Being in Older Age. Technologies, 10(2), 50–50. https://doi.org/10.3390/technologies10020050
6. Ayanouz, S., Abdelhakim, B. A., & Benhmed, M. (2020). A Smart Chatbot Architecture based NLP and Machine Learning for Health Care Assistance. Proceedings of the 3rd International Conference on Networking, Information Systems & Security. https://doi.org/10.1145/3386723.3387897
7. Beinke, J. H., Fitte, C., & Teuteberg, F. (2019). Towards a Stakeholder-Oriented Blockchain-Based Architecture for Electronic Health Records: Design Science Research Study. Journal of Medical Internet Research, 21(10), e13585. https://doi.org/10.2196/13585
8. Bhagchandani, A., & Nayak, A. (2022). Deep Learning Based Chatbot Framework for Mental Health Therapy. Advances in Data and Information Sciences, 271–281. https://doi.org/10.1007/978-981-

16-5689-7_24

9. Bharti, U., Bajaj, D., Batra, H., Lalit, S., Lalit, S., & Gangwani, A. (2020, June 1). Medbot: Conversational Artificial Intelligence Powered Chatbot for Delivering Tele-Health after COVID-19. IEEE Xplore. https://doi.org/10.1109/ICCES48766.2020.9137944
10. Bickmore, T. W., Schulman, D., & Sidner, C. L. (2011). A reusable framework for health counseling dialogue systems based on a behavioral medicine ontology. Journal of Biomedical Informatics, 44(2), 183–197. https://doi.org/10.1016/j.jbi.2010.12.006
11. Bickmore, T. W., Trinh, H., Olafsson, S., O'Leary, T. K., Asadi, R., Rickles, N. M., & Cruz, R. (2018). Patient and Consumer Safety Risks When Using Conversational Assistants for Medical Information: An Observational Study of Siri, Alexa, and Google Assistant. Journal of Medical Internet Research, 20(9), e11510. https://doi.org/10.2196/11510
12. Bruni F, Mancuso V and Pedroli E (2025) How to evaluate user experience in digital health? A scoping review of questionnaires in virtual reality applications. Front. Digit. Health 7:1561364. doi: 10.3389/fdgth.2025.1561364
13. Carter, M. (2016). Value Arguments in Science Research Articles. Written Communication, 33(3), 302–327. https://doi.org/10.1177/0741088316653394
14. Chapman, A., Hadfield, M., & Chapman, C. (2015). Qualitative research in healthcare: an introduction to grounded theory using thematic analysis. Journal of the Royal College of Physicians of Edinburgh, 45(3), 201–205. https://doi.org/10.4997/jrcpe.2015.305
15. Chukwuere, J. E. (2023). EXPLORING LITERATURE REVIEW METHODOLOGIES IN INFORMATION SYSTEMS RESEARCH: A COMPARATIVE STUDY. Deleted Journal, 1(1), 74–82. https://doi.org/10.26480/eldn.02.2023.74.82
16. Denecke, K., Cihoric, N., & Reichenpfader, D. (2023). Designing a Digital Medical Interview Assistant for Radiology. Studies in Health Technology and Informatics, 301, 60–66. https://doi.org/10.3233/SHTI230012
17. Dingler, T., Kwasnicka, D., Wei, J., Gong, E., & Oldenburg, B. (2021). The Use and Promise of Conversational Agents in Digital Health. Yearbook of Medical Informatics, 30(01), 191–199. https://doi.org/10.1055/s-0041-1726510

18. Dwaipayan Bandopadhyay, Ghosh, R., Chatterjee, R., Das, N., & Bikash Sadhukhan. (2023). Speech Recognition and Neural Networks based Talking Health Care Bot (THCB): Medibot. https://doi.org/10.1109/iccmc56507.2023.10084191

19. Esiere, Owoyi Akaninyene, & Obot, C. (2025). Methodology: A Foundation for a Good Research. Journal of Education and Practice, 5(33), 67–71. https://www.iiste.org/Journals/index.php/JEP/article/view/16976/17295

20. Francisco Pérez Peña, Matías Ibáñez Cobaisse, Sebastián Villagrán Pradena, & Alvarado, R. (2023). General aspects of the use of mixed methods for health research. Medwave, 23(10), e2767–e2767. https://doi.org/10.5867/medwave.2023.10.2767

21. Hermawan, N., Atar Fuady Babgei, & Salsanabilah. (2022). Design of Teleconsultation System with Artificial Intelligence Based Chatbot Using Docker Platform. 2022 International Conference on Computer Engineering, Network, and Intelligent Multimedia (CENIM), 26–31. https://doi.org/10.1109/CENIM56801.2022.10037290

22. Heuer, Marvin & Lewandowski, Tom & Weglewski, Joffrey & Mayer, Tom & Kubicek, Max & Lembke, Patrick & Ortgiese, Simon & Böhmann, Tilo. (2023). Rethinking Interaction with Conversational Agents: How to Create a Positive User Experience Utilizing Dialog Patterns

23. Hevner, A. (2017). The Three Cycle View of Design Science. Scandinavian Journal of Information Systems. https://www.semanticscholar.org/paper/The-Three-Cycle-View-of-Design-Science-Hevner/1fed03f8f581db40822226dd8017bf914a5994fb

24. Hevner, A., & Chatterjee, S. (2010). Design Research in Information Systems. In Integrated Series in Information Systems. Springer US. https://doi.org/10.1007/978-1-4419-5653-8

25. Hibbard, J. H., Mahoney, E. R., Stockard, J., & Tusler, M. (2005). Development and Testing of a Short Form of the Patient Activation Measure. Health Services Research, 40(6p1), 1918–1930. https://doi.org/10.1111/j.1475-6773.2005.00438.x

26. Hossain, M. A., Uddin, J., & Rahaman, M. A. (2020). IoT Based Medical Assistant Robot (Docto-Bot). https://www.semanticscholar.org/paper/IoT-Based-Medical-Assistant-Robot-(Docto-Bot)-Hossain-Qureshi/21c4c1284d83973a1345385cc57555d787bb6a7a

27. Isa, Siti Nuraishah Agos Jawaddi, & Ismail, A. (2025). Experimental Evaluation of Machine Learning Models for Goal-oriented Customer Service Chatbot with Pipeline Architecture. https://doi.org/10.21203/rs.3.rs-4532068/v1
28. Jabir, A. I., Martinengo, L., Lin, X., Torous, J., Subramaniam, M., & Tudor Car, L. (2022). Evaluating Conversational Agents for Mental Health: Scoping Review of Outcomes and Outcome Measurement Instruments (Preprint). Journal of Medical Internet Research, 25. https://doi.org/10.2196/44548
29. Ji, Z., Lee, N., Frieske, R., Yu, T., Su, D., Xu, Y., Ishii, E., Bang, Y., Madotto, A., & Fung, P. (2022). Survey of Hallucination in Natural Language Generation. ACM Computing Surveys, 55(12). https://doi.org/10.1145/3571730
30. Johannes, G., Boldt, J., & Betke, H. (2024). AIS Electronic Library (AISeL) - ECIS 2024 Proceedings: Towards a Design Theory for Task-Oriented Conversational Agents. Aisnet.org. https://aisel.aisnet.org/ecis2024/track23_designresearch/track23_designresearch/8
31. Jusoh, S., Kadir, R. A., & Al Fawareh, H. (2023). mentBot: A Repository for Mental Health Disorders*. 2023 International Conference on Consumer Electronics - Taiwan (ICCE-Taiwan), 153–154. https://doi.org/10.1109/icce-taiwan58799.2023.10227068
32. K G H Piumali, & Budditha Hettige. (2022, January 19). A Review on Existing Health Care Monitoring Chatbots. https://www.researchgate.net/publication/357929804_A_Review_on_Existing_Health_Care_Monitoring_Chatbots
33. Kadar, K. (2024). Enhancing Health Literacy and Self-Care Abilities among Individuals with Chronic Diseases. Indonesian Contemporary Nursing Journal (ICON Journal), 9(1), 3–7. https://doi.org/10.20956/icon.v9i1.33038
34. Kamali, M. E., Angelini, L., Maurizio Caon, Lalanne, D., Khaled, O. A., & Mugellini, E. (2020). An Embodied and Ubiquitous E-coach for Accompanying Older Adults Towards a Better Lifestyle. Lecture Notes in Computer Science, 23–35. https://doi.org/10.1007/978-3-030-49065-2_2
35. Kapeller, A., & Loosman, I. (2023). Empowerment through health self-testing apps? Revisiting empowerment as a process. Medicine, Health Care and Philosophy, 26(1), 143–152. https://doi.org/10.1007/s11019-022-10132-w

36. Karamanidou, C., Stamatopoulos, K., & Aliki Xochelli. (2021). Approaching Empowerment Holistically: are Physicians Willing And Able? IGI Global EBooks, 238–250. https://doi.org/10.4018/978-1-6684-2414-8.ch014

37. Kavyashree N, & J, U. (2023). MediBot: Healthcare Assistant on Mental Health and Well Being. https://doi.org/10.1109/csitss60515.2023.10334083

38. Kayser, L., Karnoe, A., Duminski, E., Somekh, D., & Vera-Muñoz, C. (2019). A New Understanding of Health Related Empowerment in the Context of an Active and Healthy Ageing. BMC Health Services Research, 19(1). https://doi.org/10.1186/s12913-019-4082-5

39. Khadija, A., Zahra, F. F., & Naceur, A. (2021). AI-Powered Health Chatbots: Toward a general architecture. Procedia Computer Science, 191, 355–360. https://doi.org/10.1016/j.procs.2021.07.048

40. Kilani, M. A., & Kobziev, V. (2016). An Overview of Research Methodology in Information System (IS). Open Access Library Journal, 03(11), 1–9. Scirp. https://doi.org/10.4236/oalib.1103126

41. Konikuzhiyil, M. H., Balasubramaniam, V., Undela, K., & Ponnusankar, S. (2022). Prediabetes Education: the Underutilized Tool of Diabetes Prevention among Indian Population. Indian Journal of Pharmaceutical Education and Research, 56(4s), s613–s619. https://doi.org/10.5530/ijper.56.4s.208

42. Kuechler, B., & Vaishnavi, V. (2008). On theory development in design science research: anatomy of a research project. European Journal of Information Systems, 17(5), 489–504. https://doi.org/10.1057/ejis.2008.40

43. Kurniawan, M. H., Handiyani, H., Nuraini, T., Hariyati, R. T. S., & Sutrisno, S. (2024). A systematic review of artificial intelligence-powered (AI-powered) chatbot intervention for managing chronic illness. Annals of Medicine, 56(1). https://doi.org/10.1080/07853890.2024.2302980

44. Lagakis, P., Logaras, E., Billis, A., Stamkopoulos, E., Dimitriadis, I., Vakali, A., & Bamidis, P. D. (2023). ClinApp: A Microservices-Based Platform for Efficient Medical Visit Scheduling. Studies in Health Technology and Informatics. https://doi.org/10.3233/shti230499

45. Liao, Q. V., Mas-ud Hussain, M., Chandar, P., Davis, M., Khazaeni, Y., Crasso, M. P., Wang, D., Muller, M., Shami, N. S., & Geyer, W. (2018). All Work and No Play? Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3173574.3173577

46. Linders, G. M., Julija Vaitonytė, Alimardani, M., Mitev, K. O., & Louwerse, M. M. (2022). A realistic, multimodal virtual agent for the healthcare domain. Zurich Open Repository and Archive (University of Zurich), 1–3. https://doi.org/10.1145/3514197.3551250
47. M. SureshKumar, Niranjan Kumar S, Chris Joel S, & Lokesh V. (2022). HELTRAK - A Medical Application with Chatbot Based on AI. 2022 1st International Conference on Computational Science and Technology (ICCST). https://doi.org/10.1109/iccst55948.2022.10040438
48. Maia, E., Vieira, P., & Praça, I. (2023). Empowering Preventive Care with GECA Chatbot. Healthcare, 11(18), 2532–2532. https://doi.org/10.3390/healthcare11182532
49. Martela, F., Hankonen, N., Ryan, R. M., & Vansteenkiste, M. (2021). Motivating voluntary compliance to behavioural restrictions: Self-determination theory–based checklist of principles for COVID-19 and other emergency communications. European Review of Social Psychology, 32(2), 1–43. https://doi.org/10.1080/10463283.2020.1857082
50. Martinengo, L., Jabir, A. I., Goh, W. W. T., Lo, N. Y. W., Ho, M.-H. R., Kowatsch, T., Atun, R., Michie, S., & Tudor Car, L. (2022). Conversational Agents in Health Care: Scoping Review of Their Behavior Change Techniques and Underpinning Theory. Journal of Medical Internet Research, 24(10), e39243. https://doi.org/10.2196/39243
51. Mesko, B., deBronkart, D., Dhunnoo, P., Arvai, N., Katonai, G., & Riggare, S. (2025). The Evolution of Patient Empowerment and Its Impact on Health Care's Future. Journal of Medical Internet Research, 27(1). https://doi.org/10.2196/60562
52. Milena Soriano Marcolino, Diniz, C. S., Chagas, B. A., Mendes, M. S., Prates, R. O., Pagano, A. S., Beatriz, M., Rodrigues, C., Borges, I. N., Raposo, M. C., Silveira, Z., Paixão, M. C., Ribeiro, L. B., Rocha, G. M., Cardoso, C. S., & Luiz, A. (2022). Synchronous teleconsultation and monitoring service targeting COVID-19: leveraging insights for post-pandemic healthcare (Preprint). https://doi.org/10.2196/preprints.37591
53. Minheere, A., Lambrechts, W., Mampaey, J., Stough, T., Caniëls, M. C. J., & Semeijn, J. (2023). Patient Power and Empowerment: Mitigating Elements of Valuable Patient Participation in Healthcare Collaboratives. Behavioral Sciences, 13(4), 347. https://doi.org/10.3390/bs13040347
54. Montagna, S., Mariani, S., & Martino Pengo. (2023). A Chatbot-based Recommendation Framework

for Hypertensive Patients. https://doi.org/10.1109/cbms58004.2023.00309

55. Muhammad, G., Md. Shourov Hasan, Umme Sadia Salsabil, & Md. Masudul Islam. (2024). Med-Lingua: A Conceptual Framework for a Multilingual Medical Conversational Agent. MethodsX, 102614–102614. https://doi.org/10.1016/j.mex.2024.102614
56. Nie, J., Shao, H., Zhao, M., Xia, S., Matthias Preindl, & Jiang, X. (2022). Conversational AI Therapist for Daily Function Screening in Home Environments. https://doi.org/10.1145/3539490.3539603
57. Offermann, P., Levina, O., Schönherr, M., & Bub, U. (2009). Outline of a design science research process. Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology - DESRIST '09. https://doi.org/10.1145/1555619.1555629
58. Osborne, R. H., Batterham, R. W., Elsworth, G. R., Hawkins, M., & Buchbinder, R. (2013). The grounded psychometric development and initial validation of the Health Literacy Questionnaire (HLQ). BMC Public Health, 13(1). https://doi.org/10.1186/1471-2458-13-658
59. Patel, M., & Patel, N. (2019). Exploring Research Methodology: Review Article. International Journal of Research & Review (Www.ijrrjournal.com), 6(3), 48–55. https://www.ijrrjournal.com/IJRR_Vol.6_Issue.3_March2019/IJRR0011.pdf
60. Patient Empowerment. (2015). Eu-Patient.eu. https://www.eu-patient.eu/policy/Policy/patient-empowerment
61. Peffers, K., Tuunanen, T., Gengler, C. E., Rossi, M., Hui, W., Virtanen, V., & Bragge, J. (2020). Design Science Research Process: A Model for Producing and Presenting Information Systems Research. ArXiv:2006.02763 [Cs]. https://arxiv.org/abs/2006.02763
62. Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. Journal of Management Information Systems, 24(3), 45–77. https://doi.org/10.2753/mis0742-1222240302
63. Pietrantoni, N. (2023). A Structured Literature Review on Conversational Agents that Empower Health Interventions. 2023 Fourth International Conference on Information Systems and Software Technologies (ICI2ST), 120–127. https://doi.org/10.1109/ici2st62251.2023.00024
64. Pracht, D., Toelle, A., & Broaddus, B. (2022). Action Research: A Methodology for Organizational Change. EDIS, 2022(1). https://doi.org/10.32473/edis-4h424-2022

65. Preininger, A. M., South, B., Heiland, J., Buchold, A., Baca, M., Wang, S., Nipper, R., Kutub, N., Bohanan, B., & Jackson, G. P. (2020). Artificial intelligence-based conversational agent to support medication prescribing. JAMIA Open, 3(2), 225–232. https://doi.org/10.1093/jamiaopen/ooaa009
66. Ramos, M. D. (2023). Exploring the relationship between planned behavior and self-determination theory on health-seeking behavior among older adults with hearing impairment. Geriatric Nursing, 52, 1–7. https://doi.org/10.1016/j.gerinurse.2023.05.001
67. Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., & Koffel, J. B. (2021). PRISMA-S: an Extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews. Systematic Reviews, 10(1). https://doi.org/10.1186/s13643-020-01542-z
68. Robbins, D. A., Mattison, J. E., & Dorrance, K. A. (2018). Person-Centricity: Promoting Self-Determination and Responsibility in Health and Health Care. Military Medicine, 183(suppl_3), 198–203. https://doi.org/10.1093/milmed/usy214
69. Roca, S., Sancho, J., García, J., & Alesanco, Á. (2020). Microservice chatbot architecture for chronic patient support. Journal of Biomedical Informatics, 102, 103305. https://doi.org/10.1016/j.jbi.2019.103305
70. Rogers, B. (2004). Research Utilization—Putting the Research Evidence into Practice. AAOHN Journal, 52(1), 14–15. https://doi.org/10.1177/216507990405200107
71. Ruvini Sanjeewa, Iyer, R., Pragalathan Apputhurai, Nilmini Wickramasinghe, & Meyer, D. (2024). Systematic Review of Empathic Conversational Agent Platform Designs and their Evaluation in the Context of Mental Health. (Preprint). JMIR Mental Health, 11, e58974–e58974. https://doi.org/10.2196/58974
72. Saraswati, P., & Devi, A. (2023). Mixed Methods-Research Methodology an Overview. Mathews Journal of Nursing and Health Care, 5(4). https://doi.org/10.30654/mjnh.100024
73. Sharma, L. R. (2022). Dealing with Crucial Aspects of Action Research. International Research Journal of MMC, 3(5), 59–74. https://doi.org/10.3126/irjmmc.v3i5.50739
74. Shneiderman, B. (2020). Human-Centered Artificial Intelligence: Trusted, Reliable & Safe. ArXiv.org. https://arxiv.org/abs/2002.04087v1
75. Singh, B., Olds, T., Brinsley, J., Dumuid, D., Virgara, R., Matricciani, L., Watson, A., Szeto, K.,

Eglitis, E., Miatke, A., Catherine E.M. Simpson, Corneel Vandelanotte, & Maher, C. (2023). Systematic review and meta-analysis of the effectiveness of chatbots on lifestyle behaviours. Npj Digital Medicine, 6(1). https://doi.org/10.1038/s41746-023-00856-1

76. SmythOS - Chatbots vs. Conversational Agents: Understanding the Key Differences. (2024, November 5). SmythOS. https://smythos.com/developers/agent-development/chatbots-vs-conversational-agents/
77. Sonnenberg, C., & vom Brocke, J. (2012). Evaluation Patterns for Design Science Research Artefacts. Communications in Computer and Information Science, 71–83. https://doi.org/10.1007/978-3-642-33681-2_7
78. Swarooprani, K. (2022). An study of research methodology. International Journal of Scientific Research in Science, Engineering and Technology, 9(3), 537–543. ResearchGate. https://doi.org/10.32628/ijsrset2293175
79. Sweta Rani Dalei. (2023). Mixed Method Research. 155–162. https://doi.org/10.58532/v2bs23p1ch12
80. Thakur, S., Rastogi, D., & Singh, L. (2022). MOODY: A Natural Language Processing-Based Chatbot for Mental Health Care. Lecture Notes in Electrical Engineering, 899–908. https://doi.org/10.1007/978-981-19-4364-5_64
81. Thomas, J. J., & Venkataraman, D. (2023). ViDepBot: Assist People to Tackle Depression Due to COVID Using AI Techniques. Lecture Notes in Networks and Systems, 379–389. https://doi.org/10.1007/978-981-19-7615-5_33
82. Vallejo, MGS. A., Ramirez, M., Gurumendi, I., & Perdomo, T. (2020). IMPORTANCE OF RESEARCH AND DRAFTING IN THE SCIENTIFIC PRODUCTION OF THE HEALTH AREA. International Journal of Research -GRANTHAALAYAH, 8(1), 83–89. https://doi.org/10.29121/granthaalayah.v8.i1.2020.251
83. Vandelanotte, C., Trost, S., Hodgetts, D., Imam, T., Rashid, M., To, Q. G., & Maher, C. (2023). Increasing physical activity using an just-in-time adaptive digital assistant supported by machine learning: a novel approach for hyper-personalised mHealth interventions. Journal of Biomedical Informatics, 104435. https://doi.org/10.1016/j.jbi.2023.104435

84. Visic, M. (2022). Connecting puzzle pieces: Systematic literature review method in the social sciences. Sociologija, 64(4), 543–562. https://doi.org/10.2298/soc2204543v
85. Vivek Katariya, Shinde Sagar Vitthal, Vitthal Sadashiv Gutte, & Manoj Devare. (2019, March 26). Intelligent Healthbot for Transforming Healthcare. ResearchGate; unknown. https://www.researchgate.net/publication/332413616_Intelligent_Healthbot_for_Transforming_Healthcare
86. Yang, H., Guo, X., Peng, Z., & Lai, K.-H. (2022). Patient empowerment in an online health platform: Exploring the quadratic effects of patients' conscious-competence on perceived health status. Computers in Human Behavior, 136, 107346. https://doi.org/10.1016/j.chb.2022.107346
87. Zeni, L., & Cristiano. (2022). The HoPE Model Architecture: a Novel Approach to Pregnancy Information Retrieval Based on Conversational Agents. Journal of Healthcare Informatics Research, 6(3), 253–294. https://doi.org/10.1007/s41666-022-00115-0

A: Appendix – Evaluation Materials in an Interview and Survey

A.1 Expert Invitation Form

Expert Survey Invitation

Health Empowerment (HE) Conversational Agent (CA)

Framework: Mapping between CA Architectural Components and HE elements

Researcher Contact: maryam.nawaz.2024@mumail.ie

Computer Science Department, Maynooth University, Ireland

Expert Email	
Designation/ Position	
Experience in Software Architecture Solutions/Development	

Please send this survey back to the given email (maryam.nawaz.2024@mumail.ie)

Disclaimer! This survey is strictly for research purposes. The data will be stored and used under the GDPR Act. You can contact (given email)anytime to withdraw your consent for this survey.

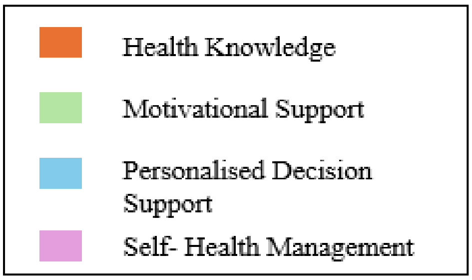
Dear Expert,

Thank you for participating in this survey. Your expertise is crucial to validate a research framework that maps the architectural components of a Conversational Agent (CA) to the core elements of **Health Empowerment (HE)**. The goal is to create a practical blueprint for designing CAs that truly empower users in managing their health.

1. Core Concept:

The research framework proposes that for a CA to be empowering, its technical architecture must be deliberately designed to support key psychological elements of empowerment.

- **Health Empowerment Elements (HEEs):** The "what" – the user-centric goals (e.g., Knowledge, Decision Support, Self-Management).
- **CA Architectural Components:** The "how" – the technical modules that deliver these goals (e.g., NLP, Dialog Manager, Knowledge Base).



2. Simplified Framework Overview

- Figure A below illustrates how CA components are conceptually linked to Health Empowerment Elements to create an empowering user experience. This research uses the following Table A for conceptual groundings to map HEEs with CA architectural components.

Table 4.2: CA Architectural Components with corresponding HEEs

CA Architectural Component	Primary linked Health Empowerment Elements (HEEs)
User Interface/	• Multiple user input types for all HEEs
Natural Language Processing (NLP)	• Health knowledge, education, and support; Personalised decision support (recommendations); Self-health management (monitoring and managing)
Classifier	• Health knowledge, education, and support; Decision making (personalized recommendations; Self-health management (monitoring and managing)
Dialog management	• Health knowledge, education, and support, Decision making (personalized recommendations, Self-health management (monitoring, and managing)
Decision support system	• Decision making (personalized recommendations); Self-health management (monitoring, and managing); Motivational support
Chatbot API	• Decision making (personalized recommendations)
Action execution	• Health knowledge, education, and support; Self-health management (monitoring and managing)
Dynamic user model	• Self-health management (monitoring and managing); Motivational support
Rule engine	• Health knowledge, education, and support
Health knowledge base expert Engine	• Health knowledge, education, and support; Decision making (personalized recommendations
Explanation Engine	• Health knowledge, education, and support; Decision making (personalized recommendations)
Cloud/Service DBs	• Health knowledge, education, and support; Decision making (personalized recommendations)
Sensor's data connectivity	• Decision making (personalised recommendations); Self-health management (monitoring, and managing)
Response generation	• Health knowledge, education, and support; Decision making (personalized recommendations); Self-health management (monitoring, and managing); Motivational support • (convert response into different types of communication)

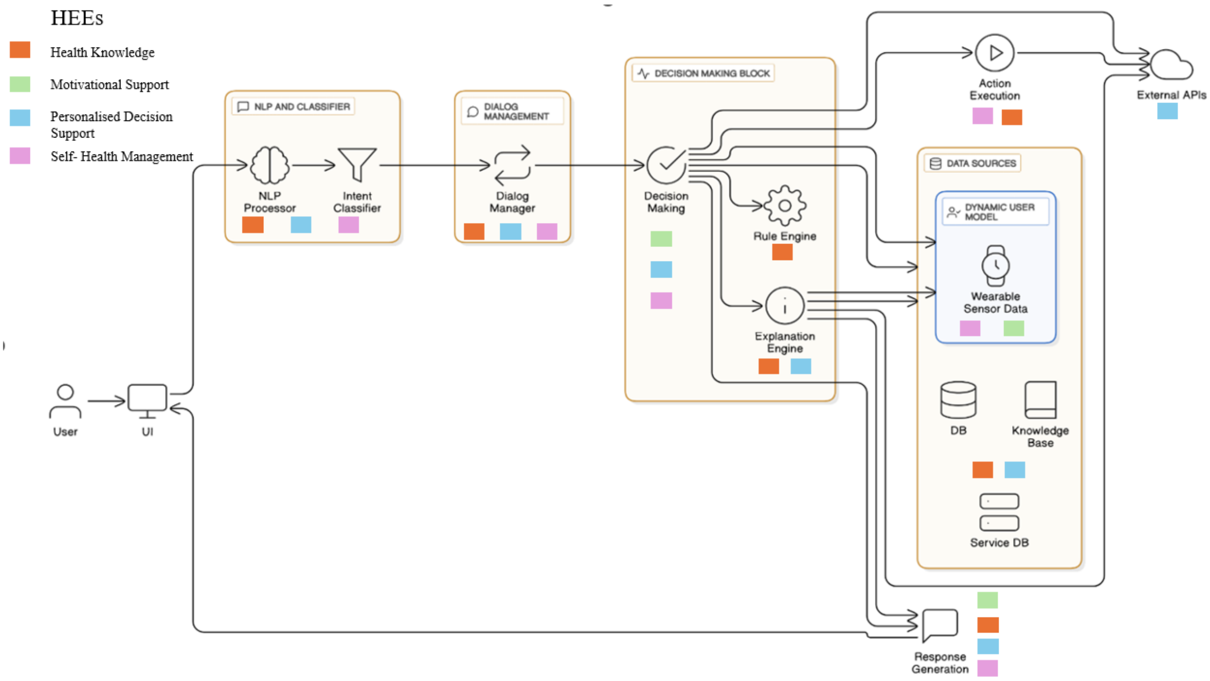


Figure A: Health CA Functional Architectural Components mapping with HEEs

A.1.1 Questions and Task Form

Instructions: Please review the provided framework (diagram and mapping table) and indicate your level of agreement with the following statements using the scale below. Your feedback is crucial for validating this research artifact.

Scale for all statements:
1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Evaluation Criteria	Evaluation Statement	1	2	3	4	5
Clarity & Understandability	The framework's components (e.g., NLP, Dialog Manager) are clearly defined. (C1)					
	The visual architecture diagram is clear and easy to interpret (U1)					
Completeness	The framework includes all essential components of a modern Conversational Agent (C2)					
Consistency & Logic	The mappings between CA components and HEEs are logical and well-justified (C3)					
	The framework is internally consistent, with no contradictory information (L1)					
Utility & Actionability	The framework provides actionable guidance for designing a health-focused CA (U2)					
	This framework successfully bridges theoretical concepts and practical system design (A1)					
Feasibility	A software architect could use this to create a high-level technical specification (F1)					
	The mapped components are technically capable of delivering the intended empowerment functions (F2)					

Qualitative Feedback:

- **What is the most important REFINEMENT needed to make this framework more rigorous or actionable?** *opportunity for iterative improvement*

  Your Answer:

- **Comments!**

A.2 Experts Survey Microsoft Form

Health Empowerment (HE) through Conversational Agents (CA): A Prototype Evaluation

This survey is based on the Health Empowerment Mapping Framework research study carried out at the Innovation Value Institute, Maynooth University.

Prototype Link: https://harp-rouge-46369429.figma.site/

Researcher Contact: maryam.nawaz.2024@mumail.ie

Disclaimer! This survey is strictly for research purposes. The data will be stored and used under the GDPR Act. You can contact (given email) anytime to withdraw your consent for this survey!

1. Please Enter your Designation, Experience in eHealth Platforms and UI Design

   Enter your answer

2. General Usability (Adapted from Patient Satisfaction and Usability with APPs & mHealth App Usability Questionnaire)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The prototype is simple and easy to navigate.	○	○	○	○	○
The interface layout (screens, buttons, text) is visually clear and well-organised.	○	○	○	○	○
I could quickly learn how to use all the features of this prototype.	○	○	○	○	○
The prototype's responses (text and recommendations) load quickly.	○	○	○	○	○

3. HEE Evaluation "Understand" Screen (Competence: Health Literacy & Education)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The answers provided are easy to understand.	○	○	○	○	○
The explanations help me learn why something is important for my health.	○	○	○	○	○
This screen would help a user feel more knowledgeable about their health condition.	○	○	○	○	○

4. HEE Evaluation "Decide" Screen (Autonomy: Personalised Decision Support)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The recommendations appear personalised (not generic).	○	○	○	○	○
The "Why this suggestion?" explanation makes the reasoning clear and transparent.	○	○	○	○	○

5. HEE Evaluation "Motivation" Screen (Relatedness + Competence: Encouragement & Support)

	Strongly Disgaree	Disagree	Neutral	Agree	Strongly Agree
The motivational messages feel authentic and supportive (not robotic or forced).	○	○	○	○	○
The messages acknowledge user progress in a way that builds confidence.	○	○	○	○	○

6. HEE Evaluation "Manage" Screen (Competence + Autonomy: Health Self-Management)

	Strongly Disgaree	Disagree	Neutral	Agree	Strongly Agree
The health data summary (e.g., steps, readings) is clear and useful.	○	○	○	○	○
The user would feel in control of managing their health tasks (e.g., reminders, goals).	○	○	○	○	○

7. Interface and User Experience (UX)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The colour scheme, fonts, and icons are appropriate for a health application.	○	○	○	○	○
The transition between screens (Understand → Decide → Manage → Motivation) is logical.	○	○	○	○	○

Microsoft excel form sheet with experts' responses on survey

Link:

https://docs.google.com/spreadsheets/d/1FP3r4zJsToB2qln5r7lpdONKVFwNWsJT/edit?gid=480272381#gid=480272381

A.3 Experts Survey Responses Summary for Analysis

Link:

https://drive.google.com/drive/u/1/folders/1zeJ6axI1FVTZgtta7zdTP0nChQtVvbjg