Universiteit Utrecht

Thesis Report

An Alternative Welcome:
Exploring the Integration of Robots in University Receptions

Graduate School of Natural Sciences

To fulfill the requirements for the degree of
Master of Science in Human-Computer Interaction

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Abstract

In recent years, the deployment of service robots has expanded beyond limited industrial applications to more interactive and social roles. This exploratory research investigates how robots can be effectively deployed into university buildings without reception desks acquiring the role of the receptionist to serve the needs of visitors. Inspired by the software development life cycle [Sommerville, 2010], the study commenced with requirements elicitation from relevant stakeholders, ensuring a user-centered design. Three methods were utilized; *Observations* in university reception environments, *Interviews* with receptionists, and *Focus Groups* with potential future users. Requirements analysis using the gathered data, produced a list of features that were implemented on *OrionStar's Greetingbot Mini* robot. The robot was then deployed in a building without a reception at *Utrecht University*, where 52 participants evaluated its design. The evaluation phase, included participants interacting with the robot and then completing a Post-Interaction Questionnaire, which comprised demographic data collection about participants and most importantly a combination of quantitative (System Usability Scale (SUS)) and qualitative (Open-Ended Questions) measures. The implemented robot was well perceived by participants, scoring a SUS Score of 84.1. Associations between SUS and the demographic data were made using statistical tests, showing no significant results and thus indicating that the design was generally accepted. Thematic analysis of the qualitative data highlighted strengths, weaknesses, and areas of improvement. The produced results served as a basis on which a final requirements list was created, which can be used as an input of recommendations for development of alike robotic solutions. Contributing to the field of Human-Robot Interaction (HRI), this research provides insights of what users expect from robots deployed in similar contexts and identifies important aspects of robot design that enhance user experience. Additionally, the study shows that robots hinder significant opportunities to enhance service provision.

Keywords: Human-Robot Interaction (HRI), Service Robots, Reception Robots, User-Centered Design, Robotic Solutions Implementation, Qualitative Methods, Quantitative Methods, Evaluation in HRI

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List of Abbreviations

HRI Human-Robot Interaction

UCD User-Centred Design

SUS System Usability Scale

API Application Programming Interface

NLP Natural Language Processing

UU Utrecht University

FG Focus Group

N/A Not Applicable

1 Introduction

The realm of robotics has witnessed significant advancements in recent years [Licardo et al., 2024]. Robots' abilities have shown amazing opportunities to provide human-like services in many different sectors [Oruma et al., 2022]. Hospitality is one of them, as it has been proven that the adoption of robots in this area, could enhance efficiency by providing fast and consistent service quality [Ivanov et al., 2017]. Moreover, nowadays, robots are seen as innovative service providers, opening the way for novel interactions and enjoyable experiences for guests [Kuo et al., 2017]. Under the area of hospitality, reception desks fall, which without any doubt, are an integral part of an establishment [Miner, 2020]. A visitor expects when entering most buildings, to find a front desk which is ready to assist with anything they might need. However, some buildings lack a reception desk. Such cases are present within *Utrecht University*, as some campus buildings do not come with an explicit reception desk. This could hinder building visitors' experiences as they struggle to find answers to their queries.

The *Faculty of Science of Utrecht University*, made the above observations, and taking into consideration results from previous studies showing that robots could provide high-quality services acting as receptionists, the motivation behind this thesis sparked; to investigate the integration of a robot receptionist in those buildings without a reception desk. The faculty proceeded to acquire in January 2024 a new robot specifically designed to provide reception services, the *GreetingBot Mini* robot manufactured by *OrionStar Robotics*, which was supplied to the University via *Zorabots Nederland*. An important note is that existing literature does not address the use of this specific robot chosen, which presents a unique opportunity for original research.

To develop and investigate the potential of a robotic receptionist utilising *GreetingBot Mini*, exploratory research was deployed. The focus was on exploring the integration of this robot in locations without a reception desk at a university while addressing user needs. Adopting a bottom-up approach, inspired by the software development life cycle's waterfall model [Sommerville, 2010], the study commenced with in-depth requirements elicitation from relevant stakeholders. Observation sessions were planned to capture unfiltered interactions within the current reception environments, identifying inefficiencies or present strengths. Semi-structured interviews with receptionists dived deeper into empirical experiences dealing with visitor queries, providing valuable insights into common visitor needs and design ideas for the robot. Focus groups explored future users' preferences and expectations from a reception robot in a collaborative setting, allowing for the generation of diverse and innovative ideas [Blandford et al., 2016]. The gathered requirements were then analyzed and implemented on the selected robot, leading up to a thorough evaluation of the developed reception robot in the real context of use. The evaluation had the purpose of informing the production of a requirements list for robots in alike environments. The research methodology adopts a holistic and user-centred approach, during all stages, ensuring the development of a reception robot that is both properly functional and well-received by the university community.

In summary, an alternative warm welcome given by a robot in a university building without a reception desk is investigated in this project. The significance of this study hides in its contribution to the field of Human-Robot Interaction (HRI). Exploration of user expectations and their integration into a robotic solution produced evaluation results that highlight the importance of user-centred design principles in developing effective service robots. This thesis aims to fill a discovered research gap by providing specific design recommendations for robotic integration in universities' non-human-assisted reception areas. The produced requirements specification list can guide the design and deployment of future receptionist robots going beyond universities, emphasizing user-reported important aspects.

Topics and research relevant to the objectives of this thesis will be analyzed in the next chapter, with the *Research Question* listed as well. The chapters following *Literature Review*, will analyze the methodology adopted, produced results will be presented and conclusions will be drawn, underlining the effectiveness of such a robotic integration.

2 Literature Review

It was critical to first understand the traditional way of providing receptionist services starting with the core of this topic, which lies in the hospitality sector. This will ensure that the developed robot serves the purpose of a receptionist effectively. Already existing robots providing reception services in multiple sectors are presented, showing the different capabilities and potential that robots have. Furthermore, the user-centred design methodology decided to be adopted for this research, was needed to be investigated to understand how it works and its importance within the field of HRI. The technical skills of robots in general and of the selected robot are presented here as well. Moreover, interface and interaction design investigated in similar projects is mentioned, informing the future design of the robot. The chapter concludes with the statement of the research question and the sub-questions formulated.

2.1 Hospitality and Receptions

Firstly, the hospitality domain includes a diverse spectrum of services that aim at providing guests with a comfortable, enjoyable, and seamless experience. This domain includes hotels, restaurants, tourism, event planning, other leisure, and more serious industries that require some form of hospitality [Jones et al., 2016]. At the heart of hospitality, is the concept of providing excellent services. The primary goal is to meet guests' expectations by offering high-quality service and interactions that are tailored to visitors[Williams, 2006].

Within this domain, the reception desk is a critical part of it, as it acts as the first point of contact between an establishment and its guests [Kandampully and Suhartanto, 2000]. The reception desk provides information, resolves queries, and has an essential role in the overall satisfaction of guests [Crick and Spencer, 2011].

2.2 Service and Hospitality Service Robots

Service robots are defined by the International Federation of Robotics, as *"A service robot is an actuated mechanism programmable in two or more axes, moving within its environment, to perform useful tasks for humans or equipment excluding industrial automation applications."* [IFR, 2021]. Service robots, are a transformative technological innovation, bringing many opportunities to hospitality [Ivanov and Webster, 2019]. In this section, the application areas of hospitality robots are shown, including shopping, urban environments, museums, hospitals and of course universities. The diverse application areas underline the versatility of service robots in adapting to different environments and user groups [Wirtz et al., 2018]. The only available suggestion for improving HRI in hospitality settings and particularly hotels is a study by [Collins, 2020], focusing on aspects related to five (5) service performance variables; *Reliability, Responsiveness, Empathy, Assurance, and Tangibles*.

As mentioned, robots have begun to transform the traditional way of service within the hospitality domain. These robots, designed to assist with various service tasks, range from delivery services to information provision and even to cleaning. Research on hospitality robots shows their potential to enhance the efficiency of operations, reduce human error, and provide consistent service quality [Ivanov et al., 2017]. Additionally, robots are seen as innovative service providers, creating new interactions and experiences for guests [Lee et al., 2021]. [Chee et al., 2010], and [Gardecki et al., 2018], explore the use of *Pepper*, a humanoid robot, in a receptionist robot role, focusing on user interactions and the effectiveness of such robots in real-world applications. The studies underline that humanoid robots can be really effective for a receptionist position. [Doering et al., 2015], and [Weiss et al., 2015], discuss the design, development, and evaluation of robots (a shopping robot, and an urban guide robot, respectively) based on user-centred approaches. The two studies focus on enhancing user experience and the importance of considering the context and environment in which the robot is deployed at.

2.2.1 Hospital and Museum Applications

Hospital and Museum environments are among the ones that reception or guide robots have been explored quite extensively. In hospitals, robots have been investigated before by [Ahn et al., 2015, Ahn et al., 2019, Gambino et al., 2019, Sutherland and et al., 2019, Johanson et al., 2020]. More recent studies on this topic, include [Ragno et al., 2023, Sommer et al., 2023a, Hwang et al., 2023]. Robots have been researched within this setting thoroughly, and because of the sensitive nature of hospitals, particular care was given to ensuring spotless service provision from robots to patients and hospital visitors. Aspects of consideration included emotional support, patient comfort, and seamless integration into the sometimes chaotic hospital environments. A paper from [Bradwell et al., 2021], gives design recommendations about robots for health and social care. Such recommendations include improved mobility and voice recognition, enhanced robustness and battery life, friendly characteristics, and humanoid features.

Within museum settings, robots have been deployed before mostly as guides. The studies investigated the potential of such solutions within this sector, focusing on aspects ranging from navigation to appearance, and interaction. Such studies include [Bennewitz et al., 2005, Shiomi et al., 2007, Kuno et al., 2007, Faber et al., 2009, Boladeras et al., 2015]. Their findings highlight the importance of effective interaction design, the usage of user-centred design, and the need to address technical challenges to ensure the development of successful and smooth tour guides carrying high-quality navigational skills.

2.2.2 University Applications

The application of robots in university campuses shows their potential beyond traditional hospitality settings. Campus robots can serve various roles, such as guiding students and visitors and providing them with needed information. The studies below, show what aspects should be considered for the future reception robot that will be deployed within this study, including types of information and applications that should be included, appearance considerations, personalization integration, clarification of purpose, interaction and guidance abilities.

[Lim and Kim, 2017], describe the development of an autonomous guide robot giving campus tours. The primary focus was given to the navigational capabilities of the robot. It used GPS and encoders mounted on its wheels. Within the study, an effective guide scenario was proposed and tested to attract the interest of visitors. The study is particular about the fact that careful and effective navigation provision design should be taken into consideration. [Onchi et al., 2016], introduces a humanoid female robot hostess for guidance in a university environment. The experiment run in the context of this paper evaluated the usefulness of the robot and its perception among users. The Godspeed scale for likeability and perceived intelligence was utilized, verifying the use of this scale for only humanoid robots. Results showed that the robot was deficient in communicating its purpose and that its movement and voice should be improved. In general, the robot was well-perceived. This study shows the importance of a robot clarifying its purpose effectively and the design of its movement and voice abilities should be carefully implemented.

[Chowdhury et al., 2020], present a university guidance robot, which was developed using Experience-Driven Design (EDD) which is a framework to design technology based on user experience goals. The *Pepper* robot was utilized and 32 participants tested the robot in a field study during orientation week. The importance of using social robots in such positions is evident, as well as evoking nurture and fellowship. These experience goals, were achieved by communicating authentic up-to-date information to students via simple and natural interaction, the robot approaching users in a human-like manner to reduce anxiety and confusion. Seven applications for the university guidance robot were created, including showing the way, restaurant services, events, finding friends, and fun and entertainment. Those seven applications inform what should be integrated into the future reception robot developed within this study. [Bellotto et al., 2008], introduces an interactive receptionist robot deployed during university open days to assist and inform visitors. The study focuses on the integration of multi-sensor information to recognize users to provide personalized services, showing the effectiveness of this solution on user experience. [Youssef et al., 2021], focuses on the design of a social robot equipped with conversational abilities, aimed at improving visitor reception services at universities. This paper combines robotic and natural language processing technologies to develop a social robot capable of making conversations with humans. Particular attention is given to designing an animatronics robotics head, with mechanisms for eyes, jaws, and neck, presenting the importance of integration of humanoid features in service robots. [Blair and Foster, 2023], discuss the future development of a robot designed to provide guidance and information at Glasgow University, in a large building designed for learning and teaching. The robot combined help-desk queries with local information about the building and surrounding campus. The requirements were gathered from stakeholders, including members of the university services, students, visitors, and a team specialized in helping students. Considered robots for this purpose included the *Furhat* and *Pepper* robots. Features for the future reception robot are discussed, including what information should be included in such a robot, which should cover the building in which the robot is deployed as well as the whole campus.

2.3 User-Centred Design

This research will adopt a user-centred design approach. User-Centered Design (UCD) methods in Human-Robot Interaction (HRI), underscore the iterative design process, incorporating user feedback to refine and optimize robot design and functionality for improved usability and user satisfaction [Pea, 1987]. This approach is essential in ensuring that robots are designed with a clear understanding of the intended users' characteristics, needs, and contexts, facilitating more effective and natural interactions between humans and robots [Doering et al., 2015].

Requirements Analysis in HRI involves a detailed investigation into the users' needs and the context in which the robot will operate. It is a foundational step in the UCD process, ensuring that the design and development efforts align with user expectations *[ISO 9241-210, 2019]*. Combined methods are usually utilised in requirements analysis, including interviews, observations, surveys, and workshops with potential users, to gather comprehensive insights into user requirements [Goodman et al., 2013]. [Prati et al., 2021], elaborate on incorporating User Experience considerations into HRI design, advocating for a user-centred approach to ensure that robots meet users' expectations and improve their overall experience. The study highlights that the body of research focuses on technological aspects neglecting human factors. Successful implementations revolve mostly around satisfying user needs in various sectors. [Khan and Germak, 2018], examines design opportunities for social robots by investigating a semi-autonomous social robot, with focus given on the integration of user experience. The study discusses that service robots should be tested to verify and evaluate positive user experiences.

[Veling and McGinn, 2021], offers a comprehensive review and categorization of qualitative research methods in Human-Robot Interaction, underscoring their importance in understanding user experiences. [Zhong and Schmiedel, 2021], demonstrate the effectiveness of combining user-centred design with agile methodologies in developing social robots for reception tasks. [Veling and McGinn, 2021], focus on the usability and requirements analysis of a service robot, underscoring the significance of intuitive design and reliability. [Green et al., 2000], explore user-centred design in intelligent service robots, stressing the incorporation of user needs for enhanced robot assistance. [Kim et al., 2011], discuss a user-centred approach to HRI research for designers, stressing the integration of user feedback into robot design. [Goodman et al., 2013] provides a guide for conducting user research, drawing attention to the importance of deeply understanding user needs and behaviours to inform design decisions.

[Han et al., 2010], gathered feedback from 36 users as they interacted with a robot receptionist. Feedback gathered, included perceptions of the robot, concerns about developing a robotic receptionist, expectations, and preferences for the robot's appearance and functionalities. The paper, emphasizes the pivotal role of following a design methodology that considers such feedback, as it enables improvements in certain aspects of robotic receptionists to take place.

2.4 Implementation

This section will provide a small overview of the general recent technical abilities of robots as well as the specification of the robot utilized within this study *GreetingBot Mini*. The current research scope is limited by the robot platform adopted by UU. Interface and interaction design aspects explored in related research are also discussed, that will inform the design of implementation of the future reception robot.

2.4.1 Technical Abilities of Robots and GreetingBot Specification

Robots come equipped with multiple advanced technological capabilities, including natural language processing (NLP), and Artificial Intelligence (AI). Robotics and rapidly improving technologies bring opportunities for innovations that transform service industries [Wirtz et al., 2018]. Advances in their hardware, have led to the development of robots that can perform complex tasks with high precision and autonomy, contributing to higher efficiency [Tussyadiah et al., 2020].

The robot selected for this study is the *GreetingBot Mini* robot manufactured by the Chinese company *OrionStar Robotics*, which was supplied to *Utrecht University* by *Zorabots Nederland*. This robot, is an advanced and intelligent robot developed to provide reception services. It was not previously used in research. It has navigational abilities as it can scan its environment with its four (4) depth cameras, radar, and anti-collision technology. The robot weighs 21 kilos and has dimensions [H: 100cm x D: 41cm]. With a single charge, its battery life spans from nine (9) to twelve (12) hours depending on usage. It is equipped with a 14-inch screen, an HD wide-angle camera, five (5) sets of speakers with noise suppression, and six (6) noise-cancelling microphones. Its processor is the Qualcomm Snapdragon 845. Zorabots supplies its robots with their operating system, which is explained in more detail in the *Methods* chapter, in the implementation section. This operating system comes with a control platform that enables remote control and the development of robot features. All the information about the robot presented here was acquired from [Zorabots, 2024]. The robot can be seen in Figure 1.

Figure 1: GreetingBot Mini Robot (derived from OrionStar Robotics)

2.4.2 Interface and Interaction Design

[Chee et al., 2010], explore enhancing human-reception robot interactions, by offering guidelines for developing appropriate communication patterns. A controlled experiment involving 6 receptionists and 10 visitors was conducted to analyze such patterns. Results show what robot receptionist designs should take into consideration to be as effective as human receptionists, including certain ways of information conveyance, friendliness, and conversation setups. The study is older and involved a small pool of participants and receptionists representing unknown establishments, and thus the findings might not be well fitting for this study. [Kantharak et al., 2017] as well, investigated the interactive capabilities of robots and adaptivity to users, focusing on the importance that such features have. In a study exploring University students' preferences for an educational robot, it was proven that students favoured interacting with the robot via speech [Eich-Stiebert et al., 2020].

[Perzanowski et al., 2001], a multi-modal interface for mobile robots was developed, that incorporates natural language and gesture recognition. The approach followed, enabled users to choose any combination of modalities which made the robot more usable. [Karunasena et al., 2019], presents an open-source robot receptionist intelligence core called *DEVI* that allows researchers to create customized robot receptionists according to certain requirements. *DEVI* can give guidance with physical gestures, answer basic queries using speech recognition, and recognize and greet people using face recognition. This work proves that social skills and appearance, are important for receptionist robots to assist people in daily activities.

2.5 Literature Review Conclusion

While there has been a significant portion of research discussing reception or guidance robots, some gaps are present. No explicit detailed requirements and design recommendations for receptionist robots exist, and in particular within university buildings without reception desks. Also, the selected robot was not previously used in research.

2.6 Research Question

Based on the above findings and gaps identified, and driven by the motivation of the newly acquired robot, this exploratory research thesis focuses on:

How can robots be effectively deployed into university buildings without reception desks to serve the needs of visitors?

The following sub-questions have also been formulated:

Sub-Q1. What are the specific functional requirements for a robot in a university reception area without a desk?

Sub-Q2. How do users at universities perceive and interact with a robot in a university reception area without a desk?

3 Methods

The research project adopted a methodology, inspired by the software development life cycle's *Waterfall Model* [Sommerville, 2010], to explore the integration of a robot in a university reception context without an explicit reception desk. This methodology started with requirements engineering, which was the most integral part of the project, as the primary goal was to try and capture user needs closely to satisfy as many potential future users as possible, ensuring user-centred design. The requirements extracted were the basis on which the interface and interaction with the robot were designed and implemented. The last step was to carry out user testing in the real context of use, to evaluate if the design was successful or not. The following sections, explain and present in detail the requirements gathering methods deployed, the process and results of analyzing those requirements, the implementation process of the expected features on the selected robot, and lastly the experimental setup to evaluate the success of the design.

3.1 Requirements Engineering

The requirements engineering approach consisted of three phases; ***Requirements Elicitation, Requirements Specification***, and ***Requirements Verification and Prioritization***. This phase was critical to extracting key design requirements from relevant stakeholders making sure that the robot's functionalities were tailored to meet future users' needs and preferences.

Starting with ***Requirements Elicitation***, the methods deployed for this research, included ***Observations, Semi-Structured Interviews,*** and ***Focus Groups***. Those methods were used frequently previously by many research papers within the field of Human-Robot Interaction (HRI), as reported in a systematic literature review of 73 papers about Quantitative Research in Human-Robot Interaction by [Veling and McGinn, 2021]. As the nature of the problem was relatively complex concerning different types of users being a part of a university environment with distinct characteristics and backgrounds, it was crucial to use multiple methods to ensure a user-centred design. The use of the three distinct methods, results in *Method Triangulation* [Thurmond, 2001, Carter et al., 2014], which increases the credibility and validity of the to produced requirements list.

As a note, the information sheets and consent forms used for all methods were built based on the guidelines and templates provided by the *Research Institute of Information and Computing Sciences* of *Utrecht University*.

3.1.1 Observations

Observations are defined by [Blandford et al., 2016], as *"Involving watching and noting what happens, and usually taking place in the situation where the technology of interest is or will be used."*

Purpose and Justification. The purpose in this context, was to observe user interactions with the current reception environment, identifying any pain points, inefficiencies, and strengths as well. Naturalistic observations, provided unfiltered insights into user behaviour in the environment of investigation. Gaps in the current reception process were revealed, which offered the opportunity to be addressed by a robot receptionist. It was a step that provided an understanding of the existing user experience, crucial for designing an effective robot. [Sommer et al., 2023b], have used observations to define user needs in a hospital reception for a service robot to be deployed.

Protocol. During each day at Utrecht University, there are six (6) time slots when courses are scheduled. The first four (4) time slots (9:00 - 10:45, 11:00 - 12:45, 13:15 - 15:00, 15:15 - 17:00), are the ones when most students and people tend to visit the university for classes and other purposes. Observations started thirty (30) minutes before each time slot started, to capture insights when most traffic is present at the entrances. The duration of each observation session was one (1) hour. Systematic notes were taken on paper, and included pain points of building visitors, where they tend to go, how often do they ask questions at the actual reception desk, and what they tend to do in the reception area.

Materials. Notebook and writing tools.

Recruitment of Participants. As the setting was needed to be naturalistic, no explicit recruitment took place. Buildings' visitors tend to stay in the reception area for a short period of time and raw interactions with the entrance setting were needed to be captured. No certain number of participants was needed to be reached. People were observed as they entered different buildings.

Due to the saturation of the findings, observations lasted only for a week (from 05/02/2024 to 09/02/2024). Thirteen (13) observations took place in total, in seven (7) different buildings. Four (4) buildings carried a reception desk (*Bolognalaan, David de Wiedgebouw, Victor J. Koningsbergergebouw, Educatorium*), and the other three (3), did not carry one (*Minnaertgebouw, Ruppertgebouw, Buys Ballotgebouw*).

3.1.2 Semi-Structured Interviews with Receptionists

Interviews according to [Blandford et al., 2016], are *"Interviewing people about their work, their experiences of technology, their hopes for future technology, etc."*.

Purpose and Justification for Selection. The purpose was to extract insights on common queries and visitor needs from experienced reception staff at reception desks. Receptionists, being the primary interface between a university and its visitors, hold plenty of experience with visitor interactions. Their insights showed frequent visitor queries or areas where human interaction is highly valued, guiding the robot's functionality design to resemble as closely as possible a receptionist. What was also needed from them was to extract their ideas for the robot's design.

Protocol. A detailed interview protocol was built based on the Semi-Structured Interviews section in the Blandford et al. Qualitative HCI Research book [Blandford et al., 2016]. The questions were developed based on a guide for Qualitative Interview Questions [Roberts, 2020]. The full protocol can be found in *Appendix A.3*. In summary, the interview sessions included introducing participants to the session and research, the main questions, and closing the interview by asking for follow-up questions. The main questions included asking receptionists about their job as well as them envisioning a future reception robot. The interviews lasted between ten (10) to fifteen (15) minutes. Notes from participants' answers were taken simultaneously by the researcher during the interview on an answer sheet. No recording was chosen to be made as the reception environment was particularly noisy, and as the interviews were short, notes were taken easily without losing any piece of information.

Materials. Information sheets and consent forms, printed answer sheets, and rewards for participants' time.

Recruitment of Participants. Participants were recruited on the spot by visiting reception desks in four (4) different buildings at *Utrecht University* (namely *Bolognalaan, Victor J. Koningsbergergebouw, Educatorium,* and *David de Wiedgebouw*), and by explaining to them in brief the research. The final number of receptionists recruited was six (6), with ages and sexes: 21 - M, 22 - F, 24 - M, 40 - M, 49 - F, 55 - F. As receptionists at the university tend to iterate their days through buildings, comprehensive insights were able to be gathered.

3.1.3 Focus Groups

According to [Blandford et al., 2016], focus groups are *"Facilitating a group discussion, most commonly between people with similar backgrounds about the theme or technology of interest."*.

Purpose and Justification. The purpose was to gather user preferences and expectations in an interactive setting. Focus groups opened a rich conversation, offering qualitative insights into what potential users would value the most from a future robot deployed in a university reception context. This was vital for user-centered design. The discussions and activities that took place within it, produced suggestions and ideas for essential features that the robot should carry.

Protocol. The ideas for activities used within the Focus Group protocol, were derived from the *Design Kit*, which is an online platform with method suggestions on applying human-centred design [Ideo.org, 2024]. In summary, the session included welcoming and instructing participants, two (2) activities for generating features for the future robot receptionist (feature generation with sticky notes and think-aloud) with a break in between and closing the session. The full protocol can be found in *Appendix A.4*.

Materials needed. Sticky notes to write important features for the robot, whiteboard and markers to list and score the features generated by participants, the robot, snacks and refreshments, voice recorder, and notepad for notes to be taken by the moderator if needed.

Recruitment of Participants. Three sessions were organized. Recruitment mostly took place via convenience sampling by sending private messages to potential participants. When the recruitment of participants was taking place, an online form was sent to them to fill out their availability for some proposed dates and time slots. Also, within the same form, the participants were provided with the information sheet (*See Appendix A.2*) to go through and learn more about the study, as well as the consent form (*See Appendix A.1*) which was given to them to consent for participation. This was done to save the time of participants during the actual focus group. They were also required to fill in their contact details, age, sex, and occupation.

Confirmation e-mail messages with the slot for which the participant was booked, were sent. The participants were reminded the day before the session. Participants were compensated with snacks and refreshments that they were able to enjoy throughout the session or take with them at the end. Fourteen participants (10 Female, 4 Male) were eventually recruited, with ages ranging from 18 to 34 years. Twelve (12) of them were students at *Utrecht University*, one (1) was a working professional, and one (1) stated their occupation as *Other*.

The following sessions took place at the *Human - Centered Computing Lab of Utrecht University (Buysballotgebouw 0.73)*, and lasted about one and half hours each:

Session Date and Time	Number of participants
27/03/2024, 11:30 - 13:00	4
08/04/2024, 11:00 - 12:30	6
11/04/2024, 15:00 - 16:30	4

Table 1: Focus Group Sessions

3.1.4 Requirements Specification

After gathering requirements from all three methods, a list with the key requirements was created (*Requirements Specification*), which was then used in the *Implementation* phase. This list, also partially answers the first sub-question *"What are the specific functional requirements for a robot in a university reception area without a desk?"*. The requirements analysis process followed here, was based on the Software Engineering book of [Sommerville, 2010].

The first step was to refine the data within each method. Identical or similar records were merged. For the feature generation activity within the focus groups, an average of the participants' ratings on the features was calculated. Then, the features were sorted based on the rating (Rating from 1 to 5). The features extracted from each method separately can be found in *Appendix A.5, Table 11 (Observations), Table 12 (Interviews), and Tables 13, 14 (Focus Groups).*

Then, the classification and organization of extracted features took place, by following the next four steps:

1. Identical or similar features from all three methods were merged, to produce enhanced requirements.
2. Extra features produced from the Focus Groups with the highest rating (equal or greater than 4.0), were included.
3. Extra ideas or features produced from all methods not mentioned in the above two, were included.
4. Features were grouped into six (6) identified categories: *Information Provision and Directions, Functional Features and Services, User Interface and Interaction, Technical Features, Appearance and Behavior, and Accessibility and Inclusivity.*

The list of requirements split into the six (6) categories mentioned above, can be found in *Appendix A.6, Table 15*.

3.1.5 Requirements Verification and Prioritization

The next step was to verify the requirements extracted. The specification list was given to two researchers for *Investigator Triangulation* to take place. This was done to confirm that the requirements were extracted from the raw data [Carter et al., 2014]. It was indeed confirmed by them that the list was comprehensive and complete. As an additional confirmation of the requirements, some of them were already identified in related research from the University of Glasgow [Blair and Foster, 2023], and Tampere University [Chowdhury et al., 2020], including providing building visitors with directions, use of clear and simple language, acquiring all the necessary information about the university, friendly attitude and appearance, provide entertainment, food options, and events information, provide contacts information, and being able to interact verbally with users. Lastly, requirements extracted were verified by [Collins, 2020], as they met the 5 *Reliability, Responsiveness, Empathy, Assurance, and Tangibles* service performance variables.

Prioritization of the features to be implemented was then followed. As with all robots, the selected robot comes with some technical limitations, and thus some of the features from the completed requirements list were not possible to be implemented. Additionally, the time frame for the thesis completion was taken into consideration. Taking these two aspects into consideration, it was particularly important to prioritize what features would actually become tangible. This was the last stage of the Requirements Specification phase, and it was done by using the MoSCOW prioritization [Hudaib et al., 2018]. The features were split into four categories: **Must have, Should have, Could have, Will not have**. The prioritization of the features can be found in the following tables, one for each category respectively (*Tables 2, 3, 4, 5*), accompanied by a short description and/or reason for exclusion or adjustment.

#	Requirement	Description
1	**Public Transportation Information**	Information about nearby public transportation options and live departures.
2	**Event Information**	Information about events organised at the university.
3	**Weather Information**	Live weather information.
4	**Lost and Found Information**	Information on how to report lost items and where to find already lost ones.
5	**Campus Information and Other Building Information**	Information about campus facilities and other campus buildings.
6	**Wi-Fi and IT Support**	Information about Wi-Fi availability, access, and IT Support.
7	**Restrooms, Prayer Rooms, Shop locations**	Locations of restrooms, prayer rooms, and shops within the building.
8	**Printing Services Information**	Information about printing services available (general and within the building).
9	**Food Options and Coffee Machine Information**	Information about available food options and coffee machines within the building and campus.
10	**Parking Availability**	Information about available parking spaces (both for bikes and cars).
11	**Campus Card Information**	Information about campus card related inquiries.
12	**Building Directory and Faculties, Opening Times, State in which building the robot is at**	Directory of the building and present faculties, opening times, and current location of the robot.

13	**Directions to Rooms/Places**	Provides directions to rooms, but only guides close to the reception area. The receptionist should be present close to the reception area at all times.
14	**Interface: Clear font**	User interface with clear and readable fonts.
15	**Interface: Simple app-like Design**	Simple and intuitive design resembling smartphone apps.
16	**Interface: Intuitive Interface Design**	User-friendly interface design.
17	**Interface: Clear, Easy way of information presentation**	Communication in clear and easy-to-understand language, simplifying dense and confusing websites.
18	**Interface: Volume control**	Ability to adjust volume on robot on screen.
19	**Interface: Discrete, Welcoming, and Kind Robot**	Robot behaves in a discreet, welcoming, and friendly manner.
20	**Interface: Interact on demand**	Ability to detect and interact with users when they approach.

Table 2: **"Must Have"** requirements with descriptions

#	Requirement	Description
21	**Interactive Campus Map**	Provides an interactive map of the campus.
22	**Accessibility for Disabled People**	Provides accessibility information and directions for disabled individuals.
23	**Autonomous Movement for Guiding Users**	Ability to move autonomously to guide users.
24	**Security Mechanisms/Privacy**	Implements security mechanisms to protect user privacy.
25	**Concise Communication and Short Messages**	Provides clear and concise communication and messages.
26	**Multi-modal Interaction**	Supports interaction via touchscreen, and speech to a certain extent.
27	**Visual Cues and Feedback**	Provides visual cues and feedback to users.
28	**Clear Indication of Purpose**	Indicates its purpose and functions.
29	**Greeting Visitors**	Using motion or face detection to greet visitors, would have made the robot bothersome as the reception area is busy with people and the robot detects motion and faces from far away. The robot only greeted visitors after the interaction was initiated.
30	**Multiple Modalities of Information Presentation**	Presents information using multiple modalities (voice, screen, images).

31	**Contact Points and Emails**	Provides numbers, emails, and contact point information for university offices and staff.
32	**Emergencies Assistance**	Information about emergency handling, and contact points.
33	**Assistance for Appointments**	Assists in picking up appointments.
34	**Assistance in Finding Study Spaces, Room Reservation Support**	Assists in finding study spaces, and supports room reservations.
35	**Smiley Face Display when Idle**	Displays a smiley face when idle.
36	**Implementation of friendly Features**	Implements friendly features such as telling jokes and providing fun facts.
37	**Call security or maintenance if needed**	Ability to call security or maintenance if required. Alternative: Provide contact points and redirection to the closest reception.
38	**Give users a list of directions of what they should do when they ask for something**	Provides in a simple way guidance on actions users should take.
39	**Voice-controlled Interactions**	Supports voice-controlled interactions to some extent. Complex to extensively set the robot to listen to any instruction.
40	**Supply visitors with stationary, feminine products, coffee cups, etc.**	Does not have the technical ability to supply visitors with items. Alternative: Redirect people to the closest reception.
41	**Mail-related Inquiries and package handling**	Does not have the technical capability to handle mail-related inquiries or packages. Alternative: Redirect people to the closest reception.

Table 3: **"Should Have"** requirements with descriptions

#	Requirement	Reason for Exclusion
42	**Multilingual Support**	Supports multiple languages including English, Dutch, and even more. Focus on implementation of other features was preferred.
43	**Integrates Natural Language Processing (NLP)**	Integrates natural language processing for more natural conversations and alternative replies. Excluded for complexity.
44	**Transparency and Honest Expression of Doubt**	Transparently expresses uncertainty or doubt when not knowing something. Excluded as NLP and extensive voice interaction will not be included.
45	**Ability to Connect to Real Persons**	Ability to connect users to real persons, such as calling someone in another building. Excluded for complexity.

46	**Weather Warnings**	Provides warnings related to weather conditions. Excluded for complexity.
47	**Adaptive Height for Varying Visitors**	Adjusts height to accommodate visitors of varying heights. Excluded, as the control of the robot's screen can be complex and physical height cannot be adjusted.
48	**Campus Map Directions**	Provides directions on the campus map. Excluded, as the reaction time of the screen is not fast enough for the purpose.

Table 4: **"Could Have"** requirements with reasons for exclusion

#	Requirement	Reason for Exclusion
49	**Customizable Appearance with Themed Lights and Decorations for Special Events**	Does not support customizable appearance or decorations.
50	**Lost and Found Services**	Does not have the technical capability to manage lost and found services.
51	**Dance or have a tune or a welcome video**	Cannot perform dances, and for this scope having a tune or a welcome video will delay interactions.
52	**Automatic volume adeptness**	The robot does not have the technical capability to adapt its volume based on the environment.
53	**NFC/QR Code/Student Card Scanning for Connectivity with university's app**	The robot does not support connectivity with such specific apps or scanning student cards.
54	**Search Box for Specific Requests**	Interface limits the addition of a search box for specific requests.
55	**Show Schedules of Lectures (individual for each student)**	The robot cannot have access to each student's schedule.

Table 5: **"Will Not Have"** requirements with reasons for exclusion

3.2 Robot Implementation

This phase is where the requirements identified above, became tangible features in the robot's design. The *"Must Have"* and *"Should Have"* features were implemented. By default coming with the robot itself, some requirements were already satisfied. These include the robot being discrete (Requirement 19), secure and respecting privacy (Requirement 24), and partially multi-modal interaction and information presentation by providing touchscreen interaction (Requirements 26, 30).

3.2.1 Implementation Platform.

Zorabots supplies its robots with their operating system. This system comes with a user-friendly platform (*ZBOS Control*) (*See Figure 2*), which enables the actions of the robot to be controlled and designed if desired (called *compositions*). Compositions can be either simple (one action executed at each time) or complex (a series of actions executed, like an algorithm). Actions include uploading, showing or playing multimedia, controlling what the robot will say and in what commands it will listen, utilizing the robot's sensors, opening websites and applications, creating loops and enabling actions under certain conditions, contacting APIs, and other features that were not relevant for the reception robot. Regarding navigation, the platform enables the creation of a map of the environment the robot is in, with the ability to enter points of interest on it, where the robot can be prompted to navigate. The movement of the whole robot, the movement of its screen (head), and its camera can be controlled. The settings of the robot can be adjusted as well. An important aspect is that it allows full remote control of the robot via local network or cloud connection.

The most integral part of the supplied operating system is the *Kiosk* as it acts as the main menu of the robot, which provides access to different compositions, media, etc. It is the interface between users and the robot. It can be customized and controlled by the platform. The design of the *Kiosk* can be found in the next sub-section about *Interface Design*. All the information about the ZBOS Control platform was extracted by [Zorabots, 2024].

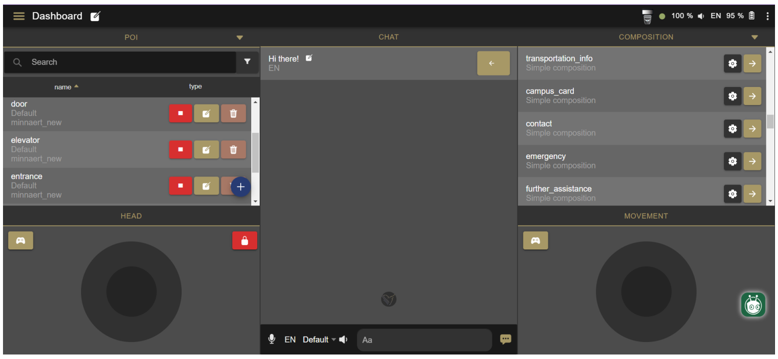


Figure 2: ZBOS Platform Interface

3.2.2 Interface Design

As mentioned in the requirements, it was expected that the robot would come with a simple app-like design (Requirement 15), with an intuitive interface (Requirement 16). The logo, fonts, and colours of *Utrecht University* were used following its Corporate Identity, ensuring that the robot receptionist feels like a part of the university. Designs were made using *Canva*. The font that the university utilizes, is clear and readable which satisfied Requirement 14. Emojis were also utilized to communicate the content better, and they served as a fun addition [Bai et al., 2019] which provided a pop of colour to the content.

Robot Face. It was expected that the robot would come with a smiley face when idle (Requirement 35), to attract building visitors, and give the robot the appearance of a formal, welcoming, and friendly receptionist (Requirement 19). The face was also designed using *Canva* (*See face in Figure 3*). How the face looked on the robot, can be seen in *Figure 6a* The appearance of the face, also indicated the purpose of the robot (Requirement 28). The logo of the university, the name of the building in which the robot was (Requirement 12), and the way of interaction initiation, were also presented on the face screen. The face was displayed when the robot was idle for more than 3 minutes. A name was also given to the robot to enhance its friendliness (Requirement 19) and its role as a receptionist. The name was “Helpy”.

Figure 3: Face of the Robot

Main Menu. The main menu, was the getaway between users and information retrieval. The main menu consisted of 16 items, based on the features that were set to be implemented. These were either folders of grouped similar features, websites, or compositions. Corresponding icons representing what is included in each item were used. The icons were derived from *uxwing.com* and enabled easy recognition of the features available [Gatsou et al., 2012] and satisfied Requirement 27 as well. This ensured the app-like design. Two (2) items, one providing information on where to reach out in case a need was not covered, and one showing information about the study and robot, were decided to be added. The order of the items within the menu was decided based on the frequency of mentions of each feature during the *Requirements Elicitation phase*. The items can be seen in the table below (*Table 6*), followed by screenshots of how the final design of the *Kiosk* looked like (Figure 4). How the menu looked on the actual robot, can be seen in *Figure 6b*.

Menu Item	Components within item (if applicable)	Requirement(s) Covered
Facilities & Amenities	Opening Hours, Special Room, Car and Bike Parking, Toilets, Food & Coffee, Study Spots in Building, Accessibility Options	7, 9, 10, 12, 22, 34
Services & Support	IT Support, Campus Card, Mail & Packages, Lost & Found, Supplies Provision, Appointment Pickup	4, 6, 11, 33, 40, 41
Directions	Building Directory, Interconnected Buildings, Elevator, Toilets/Bike Parking, Classes Directions (Lab, Lecture, Teaching Rooms)	12, 13, 23
Reserve Spaces	At the Library, At Campuses, Room Hire for Events	34
Public Transport	Information, Departures from closest Tram Station, Departures from closest Bus Station	1
Fun Stuff	University in Numbers, Tell me a Joke	36
Campus	Campus Map, Campus Information	5, 21

Wi-Fi Access	N/A, Direct presentation of information	6
How to Print?	N/A, Direct presentation of information	8
Weather	N/A, Directly opening weather application	3
Events	N/A, Directly opening website	2
Security & Maintenance	N/A, Direct presentation of information	37
Find Contacts	N/A, Directly opening website	31
Emergency	N/A, Direct presentation of information	32
Further Assistance	N/A, Direct presentation of information	Extra Addition
About	N/A, Direct presentation of information	Extra Addition

Table 6: Main Menu Items and Requirement(s) Covered

Figure 4: Main Menu Screens

Information Presentation. Information was expected to be presented merely (Requirement 17), and where applicable, clear steps on actions users should take to achieve what they need (Requirement 38) were supposed to be integrated. The simplest solution would have been to just redirect users to websites acquiring the information expected. But, this would have been contradictory to the requirements, and specifically Requirement 17 (the websites of the university are dense with information, and can be confusing). Also, the robot was not that quick in rendering websites. Direct usage of websites was made only in cases where live information or maps were needed, such as the weather (weather application), live public transportation departures (9292 - Public transport information platform) and from the UU's websites; university events, interactive campus map, university's main contact points, and IT support. How a website was rendered on the actual robot, can be seen in *Figure 6d*. For the jokes feature, an API was utilised; *Official Joke API*. The joke was presented using a text presentation feature provided by the ZBOS platform. As another fun addition, some facts about the University were also presented, which were derived from the UU website.

Information needed to cover building visitors' needs, was mainly extracted from UU's websites. The text presentation feature of the robot's platform, limited the combination of information with images, the customization of fonts and colours, and in general developing of an attractive way of conveying content. A website design was followed, and an example of the final interface design can be seen in *Figure 5*, showing the Wi-Fi feature. How this feature looked on the actual robot, can be seen in *Figure 6c*. The rest of the interface designs implementing the different features can be seen in *Appendix B.2*. Considering that the robot did not enable scroll-able text presentation, the information needed to be limited only to essentials. Thus, extra information could be accessed via QR codes, which were produced using *QRCode Monkey*.

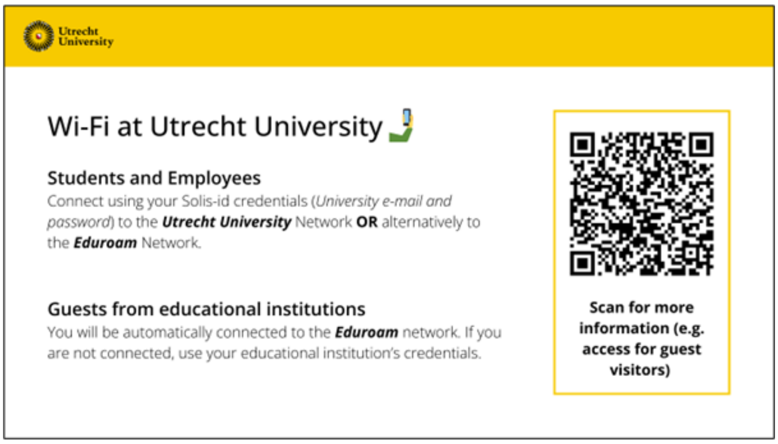
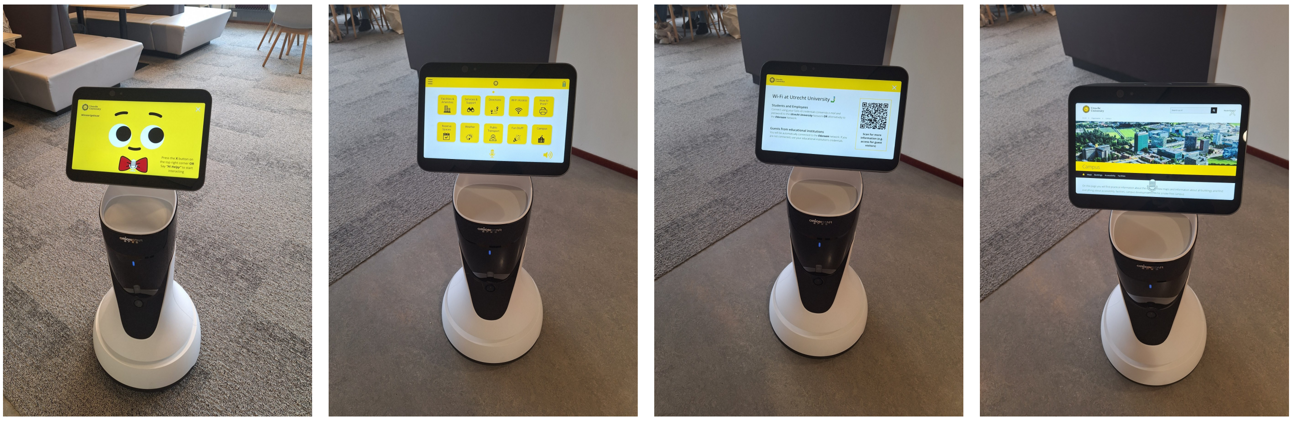


Figure 5: Example Feature - Wi-Fi

Directions Features. To implement the Directions feature of the robot, a map of the ground floor of the building where it was deployed was created using the platform. This was done by moving the robot around the main entrance area. It was decided that the robot would not move far away from the reception, as this would compromise its primary purpose of being always there to help visitors. It is worth noting, that the robot was not able to move between different floors. For other floors, a walk through the building was done to note down directions and specific locations of different points of interest, as well as building characteristics. Floor maps of the building floors were also created to indicate where classrooms are.

The robot, guided visitors only to the elevators, to the entrance door which leads to the ground floor classes, to the staircase leading to the two interconnected buildings, and to the entrance which leads to the bike parking and toilets. The robot prompted the users to "Follow me and wait for further directions". When the robot arrived at those points, it gave users some extra concise (satisfying Requirement 25) verbal instructions (*See Table 16, in Appendix B.1*), on where to find the place they were looking for. After finishing, it returned to its receptionist's position, opposite the entrance. Building visitors, were also able to choose only to be given on-screen directions, with the addition of an on-screen corresponding floor plan, showing them where their room was. Within the *Kiosk*, under the folder of Directions, classes were divided based on their type and floor, so that appropriate instructions could be given (*See Appendix B.2, Figure 12*).

Integrating designs on the robot. Different compositions were created to implement each feature. A timer was also put in each composition covering the case of a user not closing the multimedia or website active. After the timer was over, the robot was redirected back to the main menu.



(a) Face (b) Main Menu (c) Wi-Fi Feature (d) Rendering a Website

Figure 6: Robot Appearance

3.2.3 Interaction Design

Regarding navigation, when the user was in the *Kiosk*, they could slide through the menu left-right to access its two pages. If they were inside a folder, they could navigate back to the main menu, using the chevron icon or the house icon on the left bottom corner of the screen shown in Figure 7. If a composition was run (websites, multimedia, directions) a closing button at the top right corner of the screen was used to navigate back to the menu.

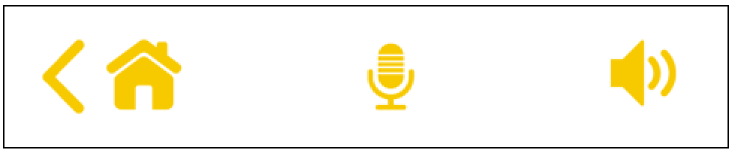


Figure 7: Navigation, Microphone, Volume Control buttons within *Kiosk*

Interaction Initiation. When a user first comes to the robot, they could initiate interaction by saying "Hi Helpy". Then, the robot provided access to the *Kiosk*, and greeted users with the following concise message: "Hi! Here is access to my menu. You can also press the microphone to tell me what you need, using one of the instructions you can find on the poster" (Requirements 25, 29). Alternatively, they could press the closing button at the top right corner of the screen if the face was presented or if a composition was already playing (*See Figure 3*). The interaction initiation integration satisfied Requirement 20.

Voice Choice and Voice Control. The voice of the robot was pre-defined. It was a male *Google* voice. It was a complex procedure to change the voice of the robot, and requirements such as voice recognition and clear language were affected negatively based on the selection. When the robot detected motion, it was actively waiting for users to press the on-screen microphone (*See Figure 7*) and speak a command. Based on specific prompts (*See Table 7*), it was programmed to open corresponding compositions. For the robot to listen in every way a visitor might ask for something, was a complex procedure which was outside of the scope of this thesis. The voice control implementation satisfied Requirements 26, 30, and 39.

Initial Prompt	Feature Prompt
I need...	Printing information, Weather information, Internet, Security, Toilet, Parking, Maintenance, A quiet room, To know opening hours, Contact details, Food and coffee, Public transport, Accessibility options, Lost and found information, Campus card information, Emergencies information, To reserve a library spot, Study spots in Minnaertgebouw, The building directory, Campus information, Human assistance, The campus map, IT support, Supplies

Table 7: Prompts recognizable by Robot

3.2.4 Alpha Testing

Extensive Alpha testing [Hai-Jew, 2019], took place after the implementation of features and interaction, to guarantee that the robot was ready to be used by actual users in the real context of use, with no bugs. During this phase, the main concern was to achieve smooth interactions and to ensure that all features were implemented and performed as expected based on the requirements specification list. When testing was completed and bugs were resolved, the robot was all set to be deployed for user testing, following the approach described in the next section.

3.3 User Testing - Evaluation

To evaluate the successful design of the robot receptionist based on the Requirements Analysis, user testing was conducted in the real context of use, at a university building at *Utrecht University* that has no explicit reception desk. The evaluation had the purpose of answering the second sub-question "How do users at universities perceive and interact with a robot in a university reception area without a desk?".

[Prati et al., 2022] and [Apraiz Iriarte et al., 2023], during their Systematic Literature review of User Experience Evaluation in Human-Robot Interaction in 2023 and 2022 respectively, did not identify a validated model to assess User Experience in Human-Robot Interaction. The *USUS Evaluation Framework for Human-Robot Interaction* proposed by [Weiss et al., 2009], suggests that qualitative methods should be combined with quantitative measures to properly evaluate Human-Robot Interactions, focusing on aspects concerning *Usability, Social Acceptance, User Experience, and Societal Impact (USUS)*. The evaluation approach adapted here, follows the framework.

3.3.1 Protocol

To measure the factors mentioned, user testing first included the interaction of potential users with the robot and observations of interactions taking place, followed by a Post-Interaction Questionnaire completed by them that included both qualitative and quantitative assessment methods. This practice, was common in many previous studies, presented with multiple variations, and suggested by reviews on evaluation in the field of Human-Robot Interaction [Bethel and Murphy, 2010, Lindblom et al., 2020, Apraiz Iriarte et al., 2023]. The analyzed protocol can be found below.

No explicit planned recruitment of participants took place, as natural interactions were preferred by those who were interested in using the robot or trying to find reception-related assistance. Those who approached the robot and interacted with its different features were potential participants in the survey. During interactions, naturalistic observations took place, and users were observed. As mentioned in [Casiddu et al., 2021], observational goals included taking notes of their facial expressions, pain points, a rough calculation for how long they have been interacting with the robot, and extra comments noted if needed. Facial expressions, seem to be particularly important when people use robots [Liu et al., 2019]. As soon as they were done with interaction and ready to leave the robot, they were approached and recruited on the spot to complete the Post-interaction Questionnaire. After giving them a brief description of the study, and only if they were interested, they were prompted to scan the QR code on the poster, which led to the survey. This was done, to ensure that they can complete the survey quickly on the convenience of their own devices. Participants were also able to read the information sheet (*See Appendix C.1*) of the study before consenting, to learn more about the study's purpose, what their interaction with the robot would involve, and what would happen with the data they provided. In return for their participation, after completing the survey, participants were provided with a snack as a reward.

The materials that were needed for the experiment, included a poster stand and a printed A3 poster to accompany the robot and invite people to test it, the actual robot, a notebook to take notes about users during interaction with the robot, and rewards for participants' time. The building selected for testing was the *Minnaertgebouw* building at *Utrecht University*, which does not include a reception desk. Permission to run the experiment was granted by the Faculty responsible for the building. The robot was placed opposite the entrance of the building so that visitors could directly see the robot when entering. The poster was designed using *Canva*, and it showed what the robot's purpose and capabilities were, how to interact with it, the research title, researcher and supervisor names, and lastly a QR code which led to the Post-Interaction Questionnaire. The poster can be seen in *Appendix C, Figure 19*. The poster was placed on a poster stand next to the robot. The setup can be seen in *Figure 8*. The researcher was sitting close to the robot, with a clear viewpoint of the interaction area. It was made sure that the researcher was not interfering with the area, and not looking as a part of the experiment.

3.3.2 Post-Interaction Questionnaire

After interaction took place, as explained above, users were approached and prompted to answer a short survey to capture their fresh and genuine impressions. The questionnaire featured a mix of quantitative scales based on standardized scales that have been used extensively to assess usability (in this case *System Usability Scale (SUS)*), and a few qualitative open-ended questions. The questionnaire was split into four (4) parts:

Figure 8: Experiment Setup

1. **Consent Form:** Participants were required to go through the consent form and state their agreement with the statements (*See Appendix C.1*).

2. **Demographic Data Questions and Features Used:** Some basic demographic data about users (important to measure as mentioned in [de Graaf, 2013]) and what features they have utilized were collected, enabling the identification of any present interaction patterns within different user groups and issues with certain features later in the analysis. Demographic data included age, sex (Male, Female, Non-Binary/Third Gender, PFNS), occupation (UU Student, UU lecturer, Visitor, Other), and existing familiarity of users with robots which is an important factor to measure [Rosén et al., 2024] (5 point Likert scale ranging from *Not familiar at all* to *Extremely familiar*). Lastly, fifteen (15) check-boxes with the robot's features (main menu items) were included in the survey, for participants to indicate what they have utilized during their interaction.

3. **System Usability Scale (SUS):** The System Usability Scale (SUS), is a simple ten-item Likert scale developed by John Brooke in 1986 and published in 1995 [Brooke, 1995], and it is widely used for subjective assessments of perceived usability [Lewis, 2018]. SUS has been used before in papers for evaluating robots in the field of Human-Robot Interaction such as [Syrdal et al., 2014, Danielsson et al., 2017]. Another widely used questionnaire in the field of HRI is the Godspeed Questionnaire, but it evaluates experiences with humanoid robots or robots in the manufacturing line which was not the case with the robot selected and scope of the thesis [Weiss and Bartneck, 2015]. SUS is a 5-point scale ranging from Strongly Disagree to Strongly Agree. The questions have been adapted to the study by changing the word "system" to "robot". Thus, the SUS questions used within the questionnaire are listed below:

(a) I think that I would like to use this robot frequently.
(b) I found the robot unnecessarily complex.
(c) I thought the robot was easy to use.
(d) I think that I would need the support of a technical person to be able to use this robot.
(e) I found the various functions in this robot were well integrated.
(f) I thought there was too much inconsistency in this robot.
(g) I would imagine that most people would learn to use this robot very quickly.
(h) I found the robot very cumbersome to use.
(i) I felt very confident using the robot.
(j) I needed to learn a lot of things before I could get going with this robot.

4. **Qualitative Questions:** These questions, allowed participants to provide in-depth insights about what they liked most and/or least about the robot's design, as well as their improvement suggestions. Similar questions have been utilized in a paper Evaluating Long-Term Human-Robot Interaction [Syrdal et al., 2014].
   (a) What did you like the most about the robot?
   (b) What did you like the least about the robot?
   (c) How do you think that the robot could be improved?

All questions were mandatory to answer, except for the qualitative questions where participants were able to leave them blank. The tool used to build the survey was *Qualtrics*, provided by Utrecht University. It was calculated that the Post-Interaction Questionnaire took 5 minutes to complete.

3.3.3 Running User Testing

When the robot was deployed in the building, its volume was adjusted accordingly to the noise of the environment, at 60%. Users had also the ability to adjust the voice via the main menu (*See Figure 7*) (Requirement 18). As the robot does not allow connection to public networks, but only private ones, a mobile hot-spot was set up, to provide an internet connection to the robot. Its head was also locked to the highest setting for more comfortable interactions of users with it.

The testing period commenced with a pilot day. The pilot, allowed preliminary feedback to be gathered, and any necessary adjustments to the protocol to take place. It also acted as a Beta Testing phase, where interaction problems were identified [Hai-Jew, 2019]. Fifteen (15) participants were recruited during the pilot day with the following demographics: Age (18 - 24: 14, 55 - 64: 1), Sex (Male: 10, Female: 5), Occupation (Students: 13, Visitor: 1, Other: 1), and Prior Familiarity with robots (Not familiar at all: 4, Slightly: 4, Moderately: 5, Very: 2). Insights were gathered by observing people interacting with the robot, and from suggestions provided within the Post-Interaction Questionnaire as well as verbally.

The main problems identified during the pilot included connectivity issues of the robot with the internet, and the inability of users to understand how to actually interact with it. Also, some users when they were in the weather application, had a hard time figuring out how to go back to the main menu. Additionally, some found the interaction prompts slightly confusing. It was calculated based on SUS scores recorded, that the robot during the pilot day, achieved a score of 75, which was higher than the average benchmark (68) and given a grade B [Lewis and Sauro, 2018]. This indicated that the issues identified might have impacted usability. More information about how the SUS score was calculated and interpreted, is given in the *Results* section. These issues were corrected, by establishing a more stable internet connection, changing the weather feature from redirection to a weather application, to a light weather website, and modifying the interaction prompts. The poster was adjusted accordingly to accommodate the robot better, with the interaction prompts listed clearly on it.

After all corrections, the final user testing phase started. It was planned to be spread over 2 weeks during weekdays (Monday to Friday), until reaching the goal of 50 participants. Data collection lasted from 09:00 to 15:00, when most people tend to visit the building. The busier time slots were identified during *Observations*, that took place during the *Requirements Gathering* phase.

In total, 52 participants with the following demographics were recruited: Age (18 - 24: 39, 25 - 34: 13), Sex (Male: 23, Female: 28, Prefer not to say: 1), Occupation (Students: 51, Other: 1), and Prior Familiarity with robots (Not familiar at all: 9, Slightly: 19, Moderately: 19, Very: 4). The final experiment days, and number of participants on each day, can be found in the following Table 8:

Date	**Number of participants**
14/05/2024 - Pilot	15
16/05/2024	12
21/05/2024	16
22/05/2024	19
23/05/2024	5

Table 8: User Testing Dates

4 Results

In this section, the User Testing results are reported, which informed the formation of the final requirements list which can serve as a starting point or a reference for robots deployed in similar contexts. The requirements lists implemented in the previous chapter were adapted based on the results of the evaluation. SUS calculation, statistical tests, and thematic analyses were conducted to transform the gathered experiment data into meaningful insights.

4.1 System Usability Scale (SUS) Calculation

To calculate the SUS score of each participant, the first step was to sum the score contributions from each item. The contribution of each item ranges from 0 to 4. For odd numbered items (1, 3, 5, 7, 9) the score contribution, was the participant's answer minus 1. For even items (2, 4, 6, 8, 10), the contribution was 5 minus the participant's answer. The sum of the scores was multiplied by 2.5 to obtain the SUS value [Brooke, 1995]. The SUS score for all participants was the average of all participants' scores. After executing the above calculations using the spreadsheet program *Microsoft Excel*, on the final experiment's data, the SUS score was calculated at 84.1. The highest score recorded was 100.0 and the lowest was 52.5. As a note, SUS scores are not interpreted as percentages or interpreted the same way as grading systems [Brooke, 2013]. As a reminder, the pilot's study score was 75.

4.2 Associations between data

Statistical tests were conducted, which had the primary purpose of identifying relationships between the data. These were executed in *Python* by utilizing appropriate libraries within the language that enable statistics analysis.

4.2.1 Demographic Data

Age groups and SUS. Two age groups were represented in the final experiment data; (1) 18 - 24 with 39 participants, and (2) 25 - 34 with 13 participants. An independent sample T-test was conducted to investigate if a statistically significant difference was present between the two age groups and SUS scores. The p-value produced, was 0.27 (> 0.05), which shows that there was no statistically significant difference in SUS scores between the two groups.

Sex and SUS. Three sexes were present in the final experiment data; Female (28 participants), Male (23 participants), and 1 (Prefer not to say). ANOVA (Single-Factor) was run over the data to investigate if there was a statistically significant difference in SUS scores between groups. The F-value was 2.96 and the p-value produced, was 0.061 (> 0.05), which shows that there was no statistically significant difference in SUS scores between the three groups.

4.2.2 Prior Familiarity with robots

Familiarity Level and SUS. Regression Analysis was run over the data, to investigate if there was a relationship between the prior familiarity of participants with robots and SUS scores. The Multiple R-value was 0.29 and (p-value $= 0.0339 < 0.05$), showing that familiarity seems to have a weak negative statistically significant influence on SUS scores. This shows that participants who were more familiar with robots tended to report lower SUS scores. Based on the coefficient calculated, for each increase in Familiarity, SUS score decreases by approximately 4.14 points. The groups were not equally populated though (Not familiar at all: 9, Slightly: 19, Moderately: 19, Very: 4), and thus the next test was decided to be conducted.

Grouped Familiarity Level and SUS. The *"Extremely Familiar"* level was not reported by any of the participants. *"Not at All"* and *"Slightly"* responses were put into one group (28 participants), and *"Moderately Familiar"* and *"Very Familiar"* into a second group (24 participants). An independent sample T-test was conducted to investigate if a statistically significant difference between the two familiarity groups (lower familiarity and higher familiarity) and SUS scores was present. The p-value produced, was 0.094 (> 0.05) showing that there was no statistically significant difference in SUS scores between the two groups.

4.2.3 Features Used

The following table shows the frequency of usage for each feature among participants, sorted from highest to lowest.

Feature	Times Used
Fun Stuff	36
Weather	30
Directions	26
Campus	14
How to Print?	11
Reserve Spaces	8
Facilities & Amenities	7
Emergency	4
Services & Support	4
Wi-Fi Access	4
Events	3
Further Assistance	3
Public Transport	3
Find Contacts	2
Security & Maintenance	2

Table 9: Frequencies of Feature Usage

Feature Influence on SUS. Regression Analysis was run over the data, to investigate if SUS scores were affected by the usage of certain features. Based on the p-values that were produced, only the Weather feature seems to have a positive significant impact on the SUS score (p-value $= 0.041 < 0.05$).

Amount of features used affecting SUS. Regression Analysis was run over the data, to investigate if SUS scores were affected by the amount of features that each participant used. Based on the Multiple R and p-value that were produced (0.17 and 0.215), there was a positive but weak relationship between the two variables and it was not statistically significant.

4.3 Observational Data

Observational data collected, included facial expressions, pain points, a rough estimation of interaction time, and extra comments (where needed). The measurements of interaction time revealed that the average interaction duration with the robot was **3.38** minutes.

Facial Expressions. The following emotions of participants were distinguished:

Emotion	Count
Neutral	19
Smiling	13
Invested - Interested	10
Excitement	9
Somewhat frustrated	1

Table 10: Observed Emotions Count

Observed Pain Points. Pain points were visible in a small amount of participants and included tall participants bending over to reach the robot, and slight confusion over finding the closing button on the top right corner of the screen. Moreover, two voice interaction issues were identified; (1) the robot not listening properly to voice instructions, and (2) participants missing the fact that they should use specific commands from the poster for the robot to understand, and use their prompts.

4.4 Qualitative Data

Thematic and Frequency Analysis [Naeem et al., 2023], was conducted to analyze the data collected about strengths, weaknesses, and suggestions for improvements from the qualitative questions within the Post-Interaction Questionnaire.

4.4.1 Strengths.

Input of participants was grouped under eight (8) distinct categories; *Overall Appearance, Features, Movement - Directions, Usability, Interaction, Inclusivity, Interface, Miscellaneous*. Two (2) participants had no input about the robot's strengths.

- **Overall Appearance.** Seven (7) participants mentioned how cute and adorable the robot was, and four (4) participants specifically mentioned that they liked the robot's face.
- **Features.** Nine (9) participants appreciated the robot telling jokes, two (2) liked its plethora of features, and one (1) found its weather feature particularly useful. QR codes were also mentioned as a positive addition.

- **Movement - Directions.** Seven (7) participants appreciated the robot's ability to move around. Others noted its capability to take them where they needed to go and its assistance in navigating through the building. Two (2) participants appreciated its clear directions for places they were looking for.
- **Usability.** Participants found the robot highly usable, with eight mentioning that it was easy to use and several noting its convenience and helpfulness.
- **Interaction.** The robot was described as very interactive by two (2) participants, friendly, and fun by four (4). They mentioned the capability of the robot to talk, and they liked that it was supporting voice interaction (mentioned by three (3) participants).
- **Inclusivity.** Participants appreciated features such as the microphone function, which made the robot accessible to people who might have difficulty reading or navigating menus.
- **Interface.** Two (2) participants liked the overall design, mentioning features such as big icons, a clear menu with distinct items, and a simple interface.
- **Miscellaneous.** Participants found the robot useful during future introduction weeks at the university and mentioned its ability to answer common queries that new students or visitors might have. Also, two (2) participants noted its spot-on location in the entrance area.

4.4.2 Weaknesses.

Input of participants was grouped under seven (7) distinct categories; *Physical Appearance, Speech - Voice Interaction, Unclear Purpose, Movement - Directions, Interaction, Interface, Features*. Twenty - three (23) participants had no input about weaknesses.

- **Physical Appearance.** Some participants noted that the robot appeared too small for effective interaction, and indicated that the screen was small.
- **Speech - Voice Interaction.** A significant issue raised by participants, was the robot's weakness in recognizing voice instructions every time. Six (6) participants reported this issue, as the robot did not respond as expected; e.g., not acknowledging the greeting "Hi Helpy". Concerns were also raised about the practicality of using voice commands in noisy campus environments. Participants noted instances where the robot's responses were unclear or confusing, and some found the voice volume level too low.
- **Unclear Purpose.** Participants mentioned challenges in understanding the robot's purpose just by its presence in the entrance area. There was a consensus that without prior interaction with it, it was difficult to understand the full range of tasks the robot could help with.
- **Movement - Directions.** Participants noted that the robot did not go all the way to specified rooms, but they also understood why it did not.
- **Interaction.** Some interaction-related issues were identified, including the robot's lack of a facial expression while interacting with it but only its presence when it was idle. Participants also reported some occasional slow response time.

- **Interface.** Issues with the interface included text being obscured by the microphone. Some participants initially found the plethora of options overwhelming, and there was slight confusion about the instruction "Press X to start". Concerns were also raised about not including more languages.
- **Features.** Some expressed dissatisfaction with the quality of jokes provided by the robot. Others found the weather information website not easily readable.

4.4.3 Suggestions.

Input of participants was grouped under seven (7) distinct categories; *Physical Appearance, Speech - Talking, Interface, Usage Instructions, Interaction, Movement - Directions, Additions*. Eighteen (18) participants had no input about suggestions for improvement.

- **Physical Appearance.** Suggestions included increasing the robot's height and size.
- **Speech - Talking.** Improvements suggested enhancing voice recognition accuracy, ensuring that the robot responds only to queries it listens to. Participants underlined the importance of adjusting voice input sensitivity and allowing varied ways of requesting information beyond fixed prompts.
- **Interface.** A participant proposed adding a screen-saver screen other than the face. Another suggested revising the sequencing of information as it felt somewhat odd. Some participants expressed a preference for integrating all necessary information within the robot's interface rather than linking to websites. Participants recommended clearer communication of the robot's purpose.
- **Usage Instructions.** Suggestions included providing a brief set of instructions directly on the robot, in addition to the Poster. One also suggested displaying sample Q & A scenarios on the starting screen to familiarize users with the way that interaction takes place.
- **Interaction.** To enhance inclusivity, participants recommended adding support for multiple languages. They also suggested increasing the robot's interaction capabilities (voice) and reducing response times.
- **Movement - Directions.** A participant proposed deploying multiple interconnected robots across different floors. Others suggested future mobility improvements to enable the robot to access a wider range of locations. Adding an interactive building map for visual route guidance was also recommended.
- **Additions.** Ideas for additional features included connecting the robot with building infrastructure such as the elevator, and real-time information provision on available nearby study spots. Participants suggested expanding the robot's range of functions to include more interactive and fun elements.

5 Discussion

The goal of this research was to investigate how can robots be effectively deployed in university buildings considering locations without desks to serve the needs of visitors. After gathering and analyzing requirements from relevant stakeholders, implementation of them took place on the selected robot, ending with an evaluation of the whole design. Within this chapter, the results produced are interpreted comprehensively, and broader implications and limitations of this study are discussed, with suggestions for future research directions closing this chapter.

5.1 Interpretation of results

Regarding the System Usability Scale (SUS) scores calculated, the final robot design had a score of 84.1. This was a significant improvement from the pilot study's score (75). It is a common goal in the industry, to achieve a SUS of at least 80 which indicates an above-average user experience, and in this case, 84.1, exceeds this goal and thus graded with an A+ [Lewis and Sauro, 2018]. The range of scores from 52.5 to 100.0 centres around a positive user perception with minimal outliers.

As mentioned by [de Graaf, 2013], variables influencing the acceptance of robots, include among others user characteristics such as age and gender. The general lack of significant differences between SUS scores and demographic characteristics of participants possibly indicates that the robot was broadly acceptable, within different ages and genders. However, as age groups were under-represented, no clear conclusion could be drawn. The same applies to genders, as not all genders were represented equally in the sample. The weak negative correlation between prior familiarity with robots and SUS scores, suggests that users who have a higher familiarity with robots might have higher expectations, resulting in slightly lower SUS scores. As mentioned by [de Graaf, 2013], variables influencing the acceptance of robots, mention control beliefs, which include familiarity with robots. The correlation is in accordance with the study of [Jokinen and Wilcock, 2017] which produced the result of participants that are more experienced with robots being more critical. At the same time, it contradicts the results of [Rosén et al., 2024] which included free interactions with the *Pepper* robot. This could be explained by the fact that the system integrated into the robot and used by [Jokinen and Wilcock, 2017] within the experiment, was an information access system by speech, which somewhat approaches the purpose and implementation of the robot deployed within this study. However, the result came from uneven groups, and thus it might not be appropriate to draw this conclusion. When familiarity levels were grouped, no such correlation was present.

The features that attracted participants mostly, were the "Fun Stuff", the "Weather", and the "Directions" features. These results indicate that there is a strong interest in engaging activities and that users appreciate fun interactions. These features introduce some human-likeness and as verified in [Belanche et al., 2021], this improves Human-Robot Interactions. The positive significant impact of the weather feature on SUS scores indicates that this feature seems to play a crucial role in the perceived usability of the robot. The extensive usage of this feature also shows that participants valued obtaining real-time weather information, especially in a rainy country such as The Netherlands. The directions feature was also highly utilized, demonstrating the importance of the robot providing navigation directions within the building, which was investigated before and reported as important by studies such as [Lim and Kim, 2017, Chowdhury et al., 2020] and studies mentioned within *Literature Review*, about *Museum Applications*. The rest of the features did not significantly affect SUS scores. The same applies to the number of features utilized by each participant. The analysis indicated a weak positive relationship between the number of features used and SUS scores, though not statistically significant. These two findings might suggest that the overall experience with the robot is more critical than focusing on individual features. The not frequent usage of some features might suggest a need for better feature visibility or that they are not that relevant to the building that the study commences or simply that they are not frequently accessed as building visitors might not need such information often.

Within the qualitative data collected, pain points observed highlighted voice interaction challenges, physical design considerations, and a small interface issue. In general, neutral (relaxed) and positive facial expressions were observed (smiling, invested - interested, excited), which show that the robot was well-received by participants, a fact that also aligns with the SUS score that was given to the robot [Liu et al., 2019]. Participants highlighted strengths, weaknesses, and suggestions for improvement on the robot design. Noted strengths across various dimensions of the robot, indicated that the robot was perceived positively among participants. The strengths highlighted what the robot's design should maintain including its appearance, interactive features, usability, and interface design. Weaknesses reported, show that improvement in speech recognition, deficient clarification of the robot's purpose, and navigational capabilities, should be considered to enhance user experience with the robot further. Those issues were identified in a previous study implementing a humanoid female robot hostess for guidance in a university environment [Onchi et al., 2016]. Although steps were taken to avoid such issues (e.g., creating a poster to help clarify the purpose of the robot), it seems that this was not the most effective approach. Speech recognition and navigational capabilities were limited by the robot selected and the scope of the research respectively. Suggestions include optimizing certain features and considering changing slightly the interface, general appearance, and interaction. Qualitative input in general, highlighted opportunities to upgrade the robot's functionality, usability, and overall user satisfaction by addressing identified areas of improvement. Similar observations were made in multiple studies such as [Doering et al., 2015, Weiss et al., 2015, Bradwell et al., 2021].

The explained results answer the second sub-question; "*How do users at universities perceive and interact with a robot in a university reception area without a desk?*". They also show that the robot achieved an excellent level of usability and user satisfaction, as indicated by high SUS scores, positive user feedback on strengths, and constructive suggestions for improvement. While some weaknesses were present, the findings confirm that the robot was well-received.

The *Requirements Specification* lists produced in the Methods section ("Must Have" and "Should Have" requirements), were adapted based on the above findings. Additions and adjustments to previous features were made, which led to the production of a comprehensive list which answers the first sub-question; "*What are the specific functional requirements for a robot in a university reception area without a desk?*". The resulting list considers user feedback and usability standards while maintaining the initial stakeholders' input and following the service performance variables for service robots [Collins, 2020]. Its focus is on optimizing the robot's performance, refining its design, and eventually impacting user experience positively. Some of the extra and adjusted requirements cannot be implemented on the robot utilized within this study, as a consequence of the limitations that come with its operating system and accompanying platform. Its hardware and physical design pose limitations as well. They are still kept though within the final list, as the purpose was to produce a list that would act as a reference for similar developments, perhaps using another robot capable of accommodating these features. Implementing the finalized requirements will likely further enhance the user experience with the robot. The full list can be found in *Appendix D*. Here, the categories of the requirements are presented in abstract:

- Interface Requirements
- Information Provision Requirements
- Interaction Requirements
- Appearance Requirements

5.2 Implications

This study provides insights into what are the specific functional requirements of users for a deployed robot receptionist in a university setting where a reception desk is not present. These insights can turn out to be valuable for other universities and institutions considering similar automation integration.

The research verified that robots can have broad applications. Robotic interventions are becoming increasingly integrated into everyday life [Licardo et al., 2024]. They show opportunities to improve services not only within university environments but also in other contexts where such services are needed. Thus, their impact should be considered on societal norms and automation of services. The challenges that were present throughout the study, in particular during implementation, show the complexity of robotic solutions. The User-Centered Design approach followed, underscores the importance of tailoring robots to specific contextual and user needs. Regarding the evaluation of robotic solution developments, this study verifies that both quantitative and qualitative methods should be utilized to enable the holistic collection of data. As there is no available detailed method in research to evaluate such solutions [Apraiz Iriarte et al., 2023], [Prati et al., 2022], this study possibly paves the way to find the best approach for evaluation in HRI. The USUS Evaluation Framework [Weiss et al., 2009] is also validated, demonstrating its applicability in real-world contexts.

These implications emphasize the significance of the research beyond the produced findings, bringing attention to its potential to contribute to the field of Human-Robot Interaction.

5.3 Limitations

Even though the study offers valuable and multiple insights into the development of a robot receptionist in a university setting where human assistance is not present, several limitations that came with it must be acknowledged.

Firstly, regarding the requirements engineering phase, extra participants could have been recruited for interviews and focus groups. Especially for the focus groups, a more diverse participant sample, could have informed the creation of the requirements list better, addressing the needs of users with other diverse characteristics. Having diverse samples is deemed extremely important by [Seaborn et al., 2023]. Unfortunately, this was not able to happen, as it was challenging to find a more diverse group of participants. As requirements that users with quite different characteristics from the ones who participated carry, the final robot design, might not satisfy them. Their acceptance of the design, could not be verified during the final experiment as well, as such participants were not a part of the participant pool. The positive aspect is that the largest group of stakeholders within a university; students, was represented.

The findings and designed functionalities of the robot were tailored specifically for a building that does not carry a reception at Utrecht University. Thus, they might not be directly generalizable to other universities, and present user demographics. Due to logistic limitations, the robot was also not tested in multiple buildings but only in one. It would have been more insightful to deploy it in other ones as well, not only to verify its effectiveness and replicability in different settings but also to attract other participants coming from diverse backgrounds with varied characteristics.

In addition, during the Implementation phase, the limitations of the robot selected for this study did not enable the implementation of some features or exactly implement others how they were communicated by relevant stakeholders during the requirements elicitation phase. The project timeline also discouraged the implementation of complex features. As a result, voice control was limited to specific prompts, limiting the robot's ability to engage more naturally with users. This could impact user experience, as many users might prefer verbal interaction over navigating over a screen [Medicherla and Sekmen, 2007]. In addition, the voice selection could have possibly been a factor that affected the user experience [McGinn and Torre, 2019]. However, for the scope of this thesis, it was not a topic of investigation. As spoken interaction was not implemented extensively on the robot, it might have minimized the effect of the voice selection on experience.

For the final experiment, a larger pool of participants would have produced more insightful results and increased the validity of the findings [Bethel and Murphy, 2010]. Regarding the demographics of the participants, older age groups (> 34) which are a part of the University environment but in smaller quantities, were not represented in the data. Although students are the largest group within a university environment, other occupations, such as lecturers and other university personnel were not represented in the sample as well (except for a few visitors). The robot was well approved by the groups that tested it, but it is unknown if this would be the case in groups from different age groups and occupations. Interactions with the robot were also short-term and provided data only about the initial interactions of potential users with it. Longitudinal studies would have produced insights into how user satisfaction and engagement evolve and whether initial positive or negative impressions persist with continued use. More methods [Bethel and Murphy, 2010], such as interviews or focus groups, could have been equipped post-interaction, to produce richer insights into areas for improvement. The SUS scoring is based on self-reported data, which can be subject to biases [Rosenman et al., 2011]. Some features of the robot were rarely used whereas others were used extensively. Rarely used features did not provide enough data to analyze their impact adequately on the overall SUS score. Lastly, the observational methods deployed during the first and last phase, are susceptible to researcher bias [Hammer et al., 2009].

In summary, while the study contributes to the body of knowledge in HRI, it came with some limitations. Addressing these limitations would help to produce more generalizable and robust conclusions.

5.4 Future Work

Looking forward, numerous opportunities for expanding this research emerge. Exploring new approaches and most importantly addressing the identified limitations could significantly advance robots deployed in similar contexts.

Regarding recruiting participants during the requirements elicitation and the testing phase, ones carrying distinct characteristics from the ones presented here [Bethel and Murphy, 2010], could inform the production of different versions of the robot which will be able to satisfy a more diverse group of participants. Such demographics include for example older age groups, disabled people, and non-student groups [Seaborn et al., 2023].

Additional experiments could be conducted to further refine the robot's design. Such experiments could provide deeper insights into aspects of the robot that were not addressed during this study, which will then inform updates on the design requirements and eventually make the robot approach a universal solution. Firstly, an investigation of what words potential users prefer to use when voice controlling such a robot will improve the voice interaction experience significantly as similarly done by [Sirithunge et al., 2021]. Voice-controlled interaction could be further developed and it could be compared with the current version in another experiment, to investigate which one is the most effective or if there is an interaction preference in specific groups of users. The optimization of this feature is important as identified by multiple studies mentioned within *Literature Review* and [Perzanowski et al., 2001, Onchi et al., 2016, Bradwell et al., 2021]. Natural Language Processing (NLP), Artificial Intelligence (AI), and Machine Learning (ML) could be integrated within the robot, making it able to personalize interactions, reply to more user queries, and thus further enhance user experience [Wirtz et al., 2018, Tussyadiah et al., 2020].

Different interface designs could be considered as well. Investigations specifically focusing on information presentation could discover a better screen design compared to the one that was chosen to be followed. Different colour choices and menu designs can be points of interest for further research. The requirements from the "*Could Have*" table (*Table 4*), could be implemented in the future. Other scales could be considered for the Post-Interaction Questionnaire [Prati et al., 2022]. Also, the deployment of deeper qualitative methods as done in [Chowdhury et al., 2020], that will have the primary purpose of grasping as many insights as possible about strengths, weaknesses, and improvement suggestions, rather than just short answers to questions, would turn out to be extremely beneficial.

The robot could be deployed in multiple buildings within the UU, or even explore its deployment in other universities and institutions, to assess the generalizability of findings across diverse environments. A longitudinal study could take place to explore how user perceptions of the robot evolve [Syrdal et al., 2014, Fraune et al., 2022]. Deployment of the robot during introduction weeks could provide insights into the robot's effectiveness and ability to handle multiple, frequent, and diverse requests as investigated in studies such as [Chowdhury et al., 2020, Bellotto et al., 2008]. The robot could also be put in a building that has a physical reception desk to evaluate its effectiveness against the traditional desk [Merkle, 2019]. This will possibly reveal opportunities for assisting receptionists or taking over tasks that could be easily automated.

In conclusion, the future holds promising opportunities for further refinement and application of the findings in a broader spectrum. Investigation of alternative user experiments and the development of robot variations can open the way toward more universally accepted robotic solutions.

6 Conclusion

The primary objective of this research was to explore how can robots be effectively deployed into university buildings without receptions to meet the needs of building visitors. Inspired by the Software development life cycle, this thesis adopted a methodology consisting of three integral phases, while constantly following a user-centred design approach. The first phase included requirements engineering with the utilization of three distinct requirement elicitation methods (Observations, Interviews, and Focus Groups), followed by analysis of gathered data. The second phase had to do with the implementation of the identified analyzed features on the selected robot *GreetingBot Mini by OrionStar Robotics*. The third and last phase included a comprehensive evaluation of the robot's design at Utrecht University with 52 participants, involving collecting qualitative user feedback and using a quantitative usability metric.

Overall, the robot was perceived positively for its usability and functionalities scoring 84.1 on the SUS scale. Users also noted multiple strengths of the design. No statistically significant results were found during the different tests, which possibly indicate that the robot is broadly acceptable. Weaknesses identified included issues having to do mostly with speech interaction. Refinement of the produced requirements specification list took place after analyzing the results and taking into consideration the suggestions of participants. This list was the main product of this research, acting as a design recommendation document for robots deployed in alike environments.

Limitations of this research included a pool of participants that was not that diverse, and deployment only within a specific university and building which might have limited the generalizability of the findings. The selected robot also posed some implementation hurdles, as not all features identified were able to be implemented. Focus on future developments should be given to improving spoken interaction, refining interface design, and enhancing features' quality.

This research contributes to the field of Human-Robot Interaction (HRI), by underlining the importance of following user-centred design principles for developing effective service robots that provide positive user experiences. Another point of contribution is that the evaluation framework used is verified, indicating that a combination of qualitative and quantitative metrics should be utilised. The getaway of this research is that constant refinement and adaptation based on user feedback is crucial to ensure user-centred design and enhancement of user experiences. Also, investigating the integration of emerging technologies with the robot such as Natural Language Processing (NLP), hinders potential to improve such robots' capabilities.

In conclusion, robots show great opportunities to assist us in many aspects of our daily lives, and more particularly, enhancing services traditionally provided only by humans. Research should continue investigating more areas in which robots could have applications. This exploratory research, investigated the deployment of a receptionist robot in university buildings without reception desks, focusing on meeting the needs of building visitors by adapting a user-centred design and executing a thorough evaluation.

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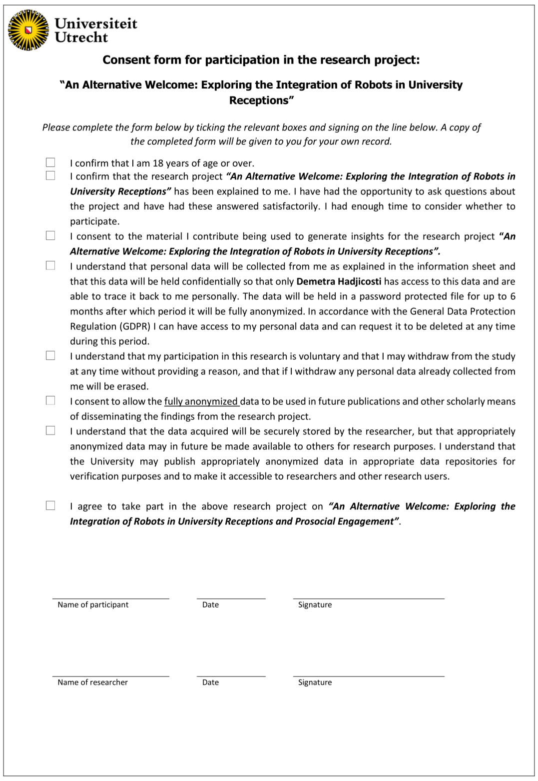
Appendices

A Requirements Engineering

A.1 Interviews and Focus Groups Consent Forms



Universiteit Utrecht

Consent form for participation in the research project:

"An Alternative Welcome: Exploring the Integration of Robots in University Receptions"

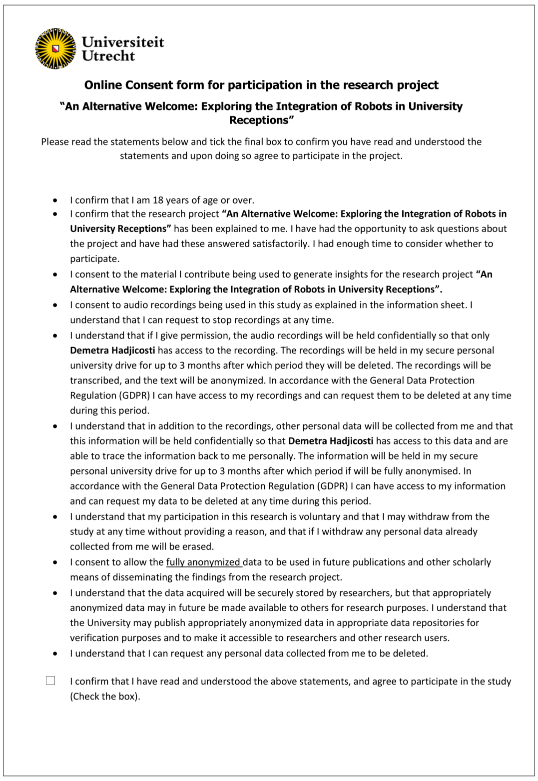
Please complete the form below by ticking the relevant boxes and signing on the line below. A copy of the completed form will be given to you for your own record.

- ☐ I confirm that I am 18 years of age or over.
- ☐ I confirm that the research project ***"An Alternative Welcome: Exploring the Integration of Robots in University Receptions"*** has been explained to me. I have had the opportunity to ask questions about the project and have had these answered satisfactorily. I had enough time to consider whether to participate.
- ☐ I consent to the material I contribute being used to generate insights for the research project ***"An Alternative Welcome: Exploring the Integration of Robots in University Receptions".***
- ☐ I understand that personal data will be collected from me as explained in the information sheet and that this data will be held confidentially so that only **Demetra Hadjicosti** has access to this data and are able to trace it back to me personally. The data will be held in a password protected file for up to 6 months after which period it will be fully anonymized. In accordance with the General Data Protection Regulation (GDPR) I can have access to my personal data and can request it to be deleted at any time during this period.
- ☐ I understand that my participation in this research is voluntary and that I may withdraw from the study at any time without providing a reason, and that if I withdraw any personal data already collected from me will be erased.
- ☐ I consent to allow the fully anonymized data to be used in future publications and other scholarly means of disseminating the findings from the research project.
- ☐ I understand that the data acquired will be securely stored by the researcher, but that appropriately anonymized data may in future be made available to others for research purposes. I understand that the University may publish appropriately anonymized data in appropriate data repositories for verification purposes and to make it accessible to researchers and other research users.

- ☐ I agree to take part in the above research project on ***"An Alternative Welcome: Exploring the Integration of Robots in University Receptions and Prosocial Engagement"***.

Name of participant Date Signature

Name of researcher Date Signature



Universiteit Utrecht

Online Consent form for participation in the research project

"An Alternative Welcome: Exploring the Integration of Robots in University Receptions"

Please read the statements below and tick the final box to confirm you have read and understood the statements and upon doing so agree to participate in the project.

- I confirm that I am 18 years of age or over.
- I confirm that the research project **"An Alternative Welcome: Exploring the Integration of Robots in University Receptions"** has been explained to me. I have had the opportunity to ask questions about the project and have had these answered satisfactorily. I had enough time to consider whether to participate.
- I consent to the material I contribute being used to generate insights for the research project **"An Alternative Welcome: Exploring the Integration of Robots in University Receptions".**
- I consent to audio recordings being used in this study as explained in the information sheet. I understand that I can request to stop recordings at any time.
- I understand that if I give permission, the audio recordings will be held confidentially so that only **Demetra Hadjicosti** has access to the recording. The recordings will be held in my secure personal university drive for up to 3 months after which period they will be deleted. The recordings will be transcribed, and the text will be anonymized. In accordance with the General Data Protection Regulation (GDPR) I can have access to my recordings and can request them to be deleted at any time during this period.
- I understand that in addition to the recordings, other personal data will be collected from me and that this information will be held confidentially so that **Demetra Hadjicosti** has access to this data and are able to trace the information back to me personally. The information will be held in my secure personal university drive for up to 3 months after which period if will be fully anonymised. In accordance with the General Data Protection Regulation (GDPR) I can have access to my information and can request my data to be deleted at any time during this period.
- I understand that my participation in this research is voluntary and that I may withdraw from the study at any time without providing a reason, and that if I withdraw any personal data already collected from me will be erased.
- I consent to allow the fully anonymized data to be used in future publications and other scholarly means of disseminating the findings from the research project.
- I understand that the data acquired will be securely stored by researchers, but that appropriately anonymized data may in future be made available to others for research purposes. I understand that the University may publish appropriately anonymized data in appropriate data repositories for verification purposes and to make it accessible to researchers and other research users.
- I understand that I can request any personal data collected from me to be deleted.

☐ I confirm that I have read and understood the above statements, and agree to participate in the study (Check the box).

Figure 9: Interviews and Focus Groups Consent Forms

A.2 Interviews and Focus Groups Information Sheets

Universiteit Utrecht

Research Participant Information Sheet - Interviews

An Alternative Welcome: Exploring the Integration of Robots in University Receptions

___/02/2024

1. Introduction

You are kindly requested to take part in an interview conducted for the purposes of gathering data in the context of a Master Thesis scientific research project in the field of Human-Computer Interaction with title ***"An Alternative Welcome: Exploring the Integration of Robots in University Receptions"***.

2. What is the background and purpose of this study?

The main goal of this research project is exploring the integration of robots into university receptions, whether in locations without a reception desk or as additional aids where receptions already exist. The general aim is to contribute to the field of Human-Robot Interaction. The interviews are a part of the Requirements Analysis phase of the research, where the purpose is to establish what is expected from such robot to have. The requirements gathered, will then inform the development of interaction on a selected reception robot.

3. Who will carry out the study?

This study is carried out by Demetra Hadjicosti (d.hadjicosti@students.uu.nl) as part of my master thesis under supervision of Maartje De Graaf (m.m.a.degraaf@uu.nl).

4. How will the study be carried out?

In this study, you will be interviewed about your work and experience as a receptionist at Utrecht University as well as providing ideas for a future reception robot. The interview will take about 10 to 15 minutes and you will be interviewed by the researcher of this study. You will receive some snacks in return for your participation.

5. What will we do with your data?

We will securely store the data you provide, namely for how long you have been working at the reception, age and gender, your opinion and ideas for a future reception robot and insights about your experience as a receptionist. As you might be identified from your age and gender, all this data constitutes personal data. We will store your gender and age separately from the rest of your data and use an ID number to link them. We will delete those data after 6 months, anonymizing your data.

6. What are your rights?

Participation is voluntary. We are only allowed to collect your data for our study if you consent to this. If you decide not to participate, you do not have to take any further action. You do not need to sign anything. Nor are you required to explain why you do not want to participate. If you decide to participate, you can always change your mind and stop participating at any time, including during the study. You will even be able to withdraw your consent after you have participated. However, if you choose to do so, we will not be required to undo the processing of your data that has taken place up until that time. The personal data we have obtained from you up until the time when you withdraw your consent will be erased (where personal data is any data that can be linked to you, so this excludes any already anonymized data).

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7. Approval of this study

This study has been allowed to proceed by the Research Institute of Information and Computing Sciences on the basis of an Ethics and Privacy Quick Scan. If you have a complaint about the way this study is carried out, please send an email to: ics-ethics@uu.nl. If you have any complaints or questions about the processing of personal data, please send an email to the Faculty of Sciences Privacy Officer: privacy-beta@uu.nl. The Privacy Officer will also be able to assist you in exercising the rights you have under the GDPR. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information at www.uu.nl/en/organisation/privacy.

8. More information about this study?

If you have any questions or concerns about this research, please contact Demetra Hadjicosti at d.hadjicosti@students.uu.nl

9. Appendices:

- Consent Form

Page 2 of 2

Figure 10: Interviews Information Sheet (1) & (2)

Universiteit Utrecht

Research Participant Information Sheet – Focus Group

An Alternative Welcome: Exploring the Integration of Robots in University Receptions and Prosocial Engagement

___/03/2024

1. Introduction

You are kindly requested to take part in a Focus Group conducted for the purposes of gathering data in the context of a Master Thesis scientific research project in the field of Human-Computer Interaction with title ***"An Alternative Welcome: Exploring the Integration of Robots in University Receptions and Prosocial Engagement"***. The Focus Groups will be conducted in the Human-Centred Computing Lab of the Department of Informatics and Computing Sciences of Utrecht University.

2. What is the background and purpose of this study?

The main goal of this research project is exploring the integration of robots into university receptions, whether in locations without a reception desk or as additional aids where receptions already exist. The general aim is to contribute to the field of Human-Robot Interaction. The Focus Group is part of the Requirements Analysis part of the research, where the purpose is to gather user preferences and expectations from such a robot. The requirements gathered, will then inform the development of interaction with a selected reception robot.

3. Who will carry out the study?

This study is carried out by **Demetra Hadjicosti** (d.hadjicosti@students.uu.nl) as part of my master thesis under supervision of **Maartje De Graaf** (m.m.a.degraaf@uu.nl).

4. How will the study be carried out?

In this study, you will participate in a focus group; you will provide your opinions and ideas about potential features and interaction suggestions for a future reception robot, in a small group setting facilitated by the researcher Demetra Hadjicosti. The facilitator will guide you through the Focus Group and will gather and take notes of your insights. The focus group will take about one hour. Refreshments, snacks, and some small handy gifts will be provided as a reward for your time.

5. What will we do with your data?

We will securely store the data you provide, namely your occupation (e.g. Bachelor/Master Student, working professional, teacher etc.), age, and your opinions and ideas about the design of a future reception robot. As you might be identified from your occupation and age, all this data constitutes personal data. We will store your occupation and age separately from the rest of your data and use an ID number to link the two. We will delete those data after 3 months, anonymizing your data.

6. What are your rights?

Participation is voluntary. We are only allowed to collect your data for our study if you consent to this. If you decide not to participate, you do not have to take any further action. You do not need to sign anything. Nor are you required to explain why you do not want to participate. If you decide to participate, you can always change your mind and stop participating at any time, including during the study. You will even be able to withdraw your consent after you have participated. However, if you choose to do so, we will not be required to undo the

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processing of your data that has taken place up until that time. The personal data we have obtained from you up until the time when you withdraw your consent will be erased (where personal data is any data that can be linked to you, so this excludes any already anonymized data).

7. Approval of this study

This study has been allowed to proceed by the Research Institute of Information and Computing Sciences on the basis of an Ethics and Privacy Quick Scan. If you have a complaint about the way this study is carried out, please send an email to: ics-ethics@uu.nl. If you have any complaints or questions about the processing of personal data, please send an email to the Faculty of Sciences Privacy Officer: privacy-beta@uu.nl. The Privacy Officer will also be able to assist you in exercising the rights you have under the GDPR. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information at www.uu.nl/en/organisation/privacy.

8. More information about this study?

If you have any questions or concerns about this research, please contact Demetra Hadjicosti at d.hadjicosti@students.uu.nl

9. Appendices:

- Consent Form

Page 2 of 2

Figure 11: Focus Groups Information Sheet (1) & (2)

A.3 Interviews Protocol

a) **Opening/Introducing Research** - Give participants the Consent Form (*See Appendix A.1*) and the Information Sheet (*See Appendix A.2*).

b) **Begin the interview** - Gather demographic data about participants namely their age, gender, and for how long they have been working at the reception.

c) **Main body of the interview - Questions**

1. Can you describe a typical day at the reception with the most common tasks you perform?
2. What information do you offer to building visitors?
3. What are the most frequent questions or requests you receive from visitors?
4. Have you noticed any common behaviors or needs among different types of visitors?
5. Are there any repetitive or routine inquiries that you think could be automated?
6. Are there any big challenges that you face and situations where you find it difficult to manage the reception area effectively?
7. If you could design the ideal reception robot, what essential features or functions would it have?
8. What do you think would be the visitors' reaction to interacting with a robot at the reception?
9. How do you think a reception robot could assist in your daily tasks or impact your job?
10. Do you have any concerns about integrating a robot into the reception area?
11. How do you imagine the interface of this robot looking like?

d) **Closing the interview**

- Ask follow-up questions if deemed necessary.
- "Is there anything else you would like to share that was not covered?"
- Thank participant for their time and contribution, and provide them with their reward in return for their participation.

A.4 Focus Group Protocol

1. **Welcome, Introduce participants to the session and to each other (10 minutes):** Participants got welcomed to the session, and they met each other. The facilitator introduced participants to how the session would roll, and the recording started.

2. **Extracting features (30 minutes):** Participants were given sticky notes, and they were prompted to: "Write down as many features as you can think for a reception robot deployed in a building at university without a reception using a sticky note for each one". Participants had 10 minutes to do so. Afterwards, the moderator gathered the sticky notes. Similar features were merged and then listed on the whiteboard. An iteration through the features took place and all participants ranked each feature based on the following 5-point Likert scale: (5) Essential, (4) Beneficial, (3) Neutral opinion, (2) Optional, (1) Unnecessary. This is a modified scale of MoSCOW prioritization which is used for prioritizing requirements in a collaborative manner, with the added option of neutrality [Hudaib et al., 2018].

3. **Short Break (10 minutes)**

4. **A think-aloud approach (20 minutes):** The robot selected for the study was shown to the participants. Then participants were prompted to describe in short how they think such a robot should be acting, its interface aspects, their potential concerns, and what they expect from it. Notes were taken from the moderator (researcher) during this time with the participants' input.

5. **Closing the session:** Thank participants for their time, and allow them to add anything that they wanted to.

6. **Storing data:** Pictures of the whiteboard were taken, and the think-aloud approach was transcribed from the audio recording.

A.5 Requirements Extracted from each method

Observations - Features
Directions are really needed with clear instructions
Directions to classes
Directions to specific rooms/offices
Returning or borrowing stuff from the receptions
Wi-Fi Code Information
People with disabilities entering the reception - robot should be disability friendly
Pick-up appointments
Campus card information and printing
Lost and found
Minimise reception waiting times

Table 11: Observations - Extracted features

Interviews - Features
Provide campus card information
Printing services information
Supply visitors with stationary, feminine products, coffee cups, band aids, microphones, keys, pointers, markers
Call security or maintenance if needed
Offer directions and guidance to rooms and other locations within the campus
For specific inquiries – give them a list of directions of what they should do
Share information on parking availability
Opening times
Assist with laptop lending, room reservations, and bike rentals
Provide contact emails for specific needs
State on which building the robot is at
Providing users with appropriate contact points, e-mails
Provide quick access to human assistance when necessary via calling
Display location information and maps
Have a map of the building
Offer up-to-date information on building facilities and events
Provide building directories and departmental information
Offer information about food options and coffee machines
Share current schedules of lectures and room availability
Assist in making reservations for rooms or equipment

Provide guidance on facility locations (prayer rooms, restrooms, shop, lockers)
App-like design with clickable icons for ease of use
Display information in clear language and fonts, simple way of presentation
Greet visitors
Walking with you
Approachable robot
Pick up appointments via stating the phone number or QR code
Be visible
Offer assistance for visually impaired users
Provide support for elderly or disabled individuals
Assist with lost and found items
Have different languages
Provide voice-controlled interactions
Offer schedules
Wi-Fi codes
Emergencies support
Public transport information
Assist with mail-related inquiries and package handling
Ensure robust development to avoid fragility
Maintain approachability for shy users
Simple and intrinsic interface
Clear language and fonts

Table 12: Interviews - Extracted Features

Focus Groups - Feature Generation	**Rating**
Transparency, Express doubt honestly	5.000
Having all the info of the building that it is at, available	5.000
Campus Information, Other Building Information	5.000
Security Mechanisms/Privacy	5.000
Accessible for disabled people (Speech/Short for wheelchairs/Adaptive route to elevators)	5.000
Interact on demand	5.000
Open you doors for specific rooms with special access	5.000
Directory of all the rooms at building (explain how room numbers work etc.)	5.000
Provide directions to rooms	4.875
English and Dutch (maybe other languages as well, is a plus)	4.830
Intuitive, not needing help to start using it and people will want to use it	4.830

Disability information about toilets/elevators	4.750
Simple Interface	4.750
Noise cancelling/isolation	4.750
FAQ (directions, internet, connectivity issues, IT support)	4.670
Call someone at another building (video call), someone can come over, Redirect you to a staff member if needed, suggesting who to call, ability to connect to a real person	4.638
Map of the building (Showing the route), Show map of the building (directions, pointing, landmarks, QR code to scan and take you)	4.625
Concise Communication, Short messages	4.625
Alternative replies	4.500
Campus card, and card printing information	4.500
Discrete robot	4.500
Kind Voice	4.500
Voice input and output	4.500
Multi-modal way of interaction (touch screen/speech/buttons)	4.416
Event information, Ability to know what is happening in building	4.375
Visual Cues and Feedback, Screen Based/Visual help	4.290
Be visible at a fixed position	4.250
Clear indication of purpose	4.250
Multiple modalities of showing the info	4.250
Directions to other buildings	4.250
Printer information and status	4.210
Friendly and welcoming (not creepy), Approachable	4.125
Interactive map of campus	4.000
Emergencies Handling, Direct people out of the building in case of emergency	3.943
Do everything a receptionist does, and serve the purpose of the receptionist only	3.875
Find Faculties	3.830
Suggesting the best route to somewhere	3.750
Adjustable screen/font/settings	3.750
Adjustable volume	3.750
Transportation Information	3.750
Ability to connect Wi-Fi/QR code	3.750
Special room information	3.670
Lost and Found, Storing lost and found	3.540
Point at a target direction	3.500
Finding certain people + room (advisor, psychologist, mentor, ICT helper)	3.500
State distance by bike/walking within building	3.500

Be noticeable not a distraction	3.330
Bathroom information	3.330
Information about room availability, Schedule of reserved rooms, Class schedule, see what room is reserved	3.330
Having a real conversation not Q/A, Live chat	3.250
Opening hours of building	3.250
Not uncanny, Not having a face, Not looking like a human	3.028
Student association activities display (marketing purposes – ask to display something)	3.000
Where to park	3.000
Find food places, Recommendations for food/drink in the building or nearby, Food place information based on your needs	2.943
Adaptive speech speed, if you hurry or if not understanding	2.830
Record reports of defects	2.750
Rules of Building – COC	2.750
Share directions to someone's phone/e-mail address	2.750
Walk with you	2.500
Have a greeting	2.500
Information about vending machines	2.500
Personalized information and advice, Identify you when standing in front of it, Recognition/Identification ways	2.416
Bubbly, Confident, Welcoming personality, Sense of humor	2.375
Borrow items (chargers, paper, basic medicine), info about borrowing, Stationary Supplies	2.335
Male and female voice choice	2.250
Suggest study spots based on availability, and general suggestions	2.165
Animal Like – cute version	2.000
Emotion recognition and adeptness	1.750
Coffee machine information	1.670
Facial Expression, Wave and smile	1.625
Feminine Products	1.585
Application to university information	1.500

Table 13: Focus Groups - Feature Generation

Focus Groups - Think-Aloud
Ability to track its own location if it moves around, so that if it is not in the reception area, people know
Adaptive height to accommodate visitors of varying heights
Uses a simple interface with larger text and icons
Fill up the screen
Provides clear indication of its purpose and capabilities
Customizable appearance with themed lights for different occasions
Greets visitors with “Hi, how can I help you?” upon approach
Uses voice interaction initially; options appear on screen if voice command is unclear
Integrates natural language processing (like ChatGPT) for conversational interactions, more personal
NFC or QR code scanning or other way for connectivity with your UU app
Weather information
Provide with transportation options in accordance with weather conditions
Offers assistance in finding study spaces
Reserving rooms – show availability and book on the spot, or provide QR codes to book it with phone
Have on the tray items like candy or stationery
Recommendations of questions to ask
Quick interactions
Implements Google Nest-like features (e.g., telling jokes, recognizing birthdays)
Assists in finding specific professors or rooms quickly
Offers personalised assistance based on individual schedules
Provides visual cues and feedback during interactions
Uses visual cues (e.g., active listening icon) for enhanced user experience
Uses mapping features to avoid obstacles and navigate efficiently
Features a user-friendly interface with clear icons and options
Displays a 3D map and FAQs for easier navigation and information retrieval
Have a smiley face when not used
Direct you to a receptionist if the request becomes really complex
Dance or have a tune or a welcome video
Moving might be unnecessary
During introduction week – have the schedule of activities on there to help new visitors
Decorate it according to special events
Not have a name
Have a search box to type in requests
Utilises visual cues and feedback during interaction

Provides voice activation for visually impaired users
Scans student IDs or timetables for personalised assistance
Offers a range of interaction patterns based on user preferences
Can alternate between male and female voices for variety
Put signs to clarify its role as a receptionist
Invites users to interact with a “Come, Try me out” message
Decorate with themed lights
Maintains a stationary position for easy accessibility, especially for individuals with disabilities
Noise adaptiveness
Provides options for different types of user interactions (e.g., touch, voice)
Indicate purpose

Table 14: Focus Groups - Think-Aloud

A.6 Full requirements list before prioritization

Category	Features
Information Provision	Wi-Fi, Weather and warnings, Restrooms, Prayer Rooms, Shops, Locker locations, State in which building the robot is, Printing services, Food Options and coffee machines, Parking availability, Events, Public transportation, Campus card/card printing, Opening times, Directions to rooms/offices, Campus and other buildings, Building directory and faculties listing, Schedules of lectures, Contact points and emails, Emergencies
Functional Features and Services	Lost and found, Assistance in appointment management (Pickup via QR Code or Phone Number), Finding study spaces, Room reservation support (show availability and book on the spot, or provide QR codes to book it with phone), Recommendations for questions to ask, Friendly features (e.g. telling jokes, recognizing birthdays), Transparency and honest expression of doubt, Ability to connect to real persons (e.g., call someone at another building, have someone come over), Call security or maintenance, Supply visitors with stuff they might need (stationary/feminine-health products/devices), Mail-related inquiries and package handling, IT Support
User Interface and Interaction	Greeting Visitors, Search box for specific requests, Simple design (app-like), Clear-Easy way of information presentation, Clear font, Voice-controlled interactions, Concise Communication and short messages, Alternative replies if the user is not satisfied, Multi-modal Interaction (Touchscreen, Speech, Buttons), Visual cues and feedback, Clear indication of robot's purpose, Multiple modalities for information presentation, Interactive campus map with directions, Intuitive interface design, Give users a list of directions of what they should do when they ask for something
Technical Features	Adaptive height for varying visitors, Autonomous movement for guiding users, NFC or QR code scanning for connectivity with UU app, Recognize when someone is standing in front of it to interact on demand, Security mechanisms/privacy, Integrates natural language processing for more personal conversational interactions
Appearance and Behavior	Customizable appearance with themed lights, Discrete, Welcoming, and kind robot, Smiley Face when idle, Dance or have a tune/welcome video, Noise adeptness/cancelling, Decorations for special events
Accessibility and Inclusivity	Multilingual support (English, Dutch, and potentially other languages), Accessibility for disabled people (Adaptive Routes, speech for visually impaired ones)

Table 15: Requirements List before Prioritization

B Implementation

B.1 Voice Interaction

Directions to [...]	Spoken Instruction
Elevators	Here is the elevator taking you to the first and second floor. Have a nice day!
Toilet and Bike Parking	Go in the door, toilets to your left, for bike parking continue straight. Have a nice day!
Interconnected Buildings	Go upstairs and turn to your right in the glass door to enter KBG. From that building you can find Spar and access BBG as well. Have a nice day!
Teaching/Tutorial Rooms - Ground Floor	You can find your teaching room in the first rooms when entering the aisle after this door. 0.15 is to your left before this door. Have a nice day!
Teaching/Tutorial Rooms - Second Floor	At the end of this corridor, you can find stairs and an elevator leading you to the second floor where you can find your teaching room. Have a nice day!
Lab Rooms	Here is the entrance to the aisle that leads you to the lab rooms. You can find them at the end of the corridor. Have a nice day.
Lecture Halls	At the end of this corridor after this door, you can find stairs and an elevator leading you to the second floor where the lecture halls are. Have a nice day!

Table 16: Spoken Directions

B.2 Interfaces

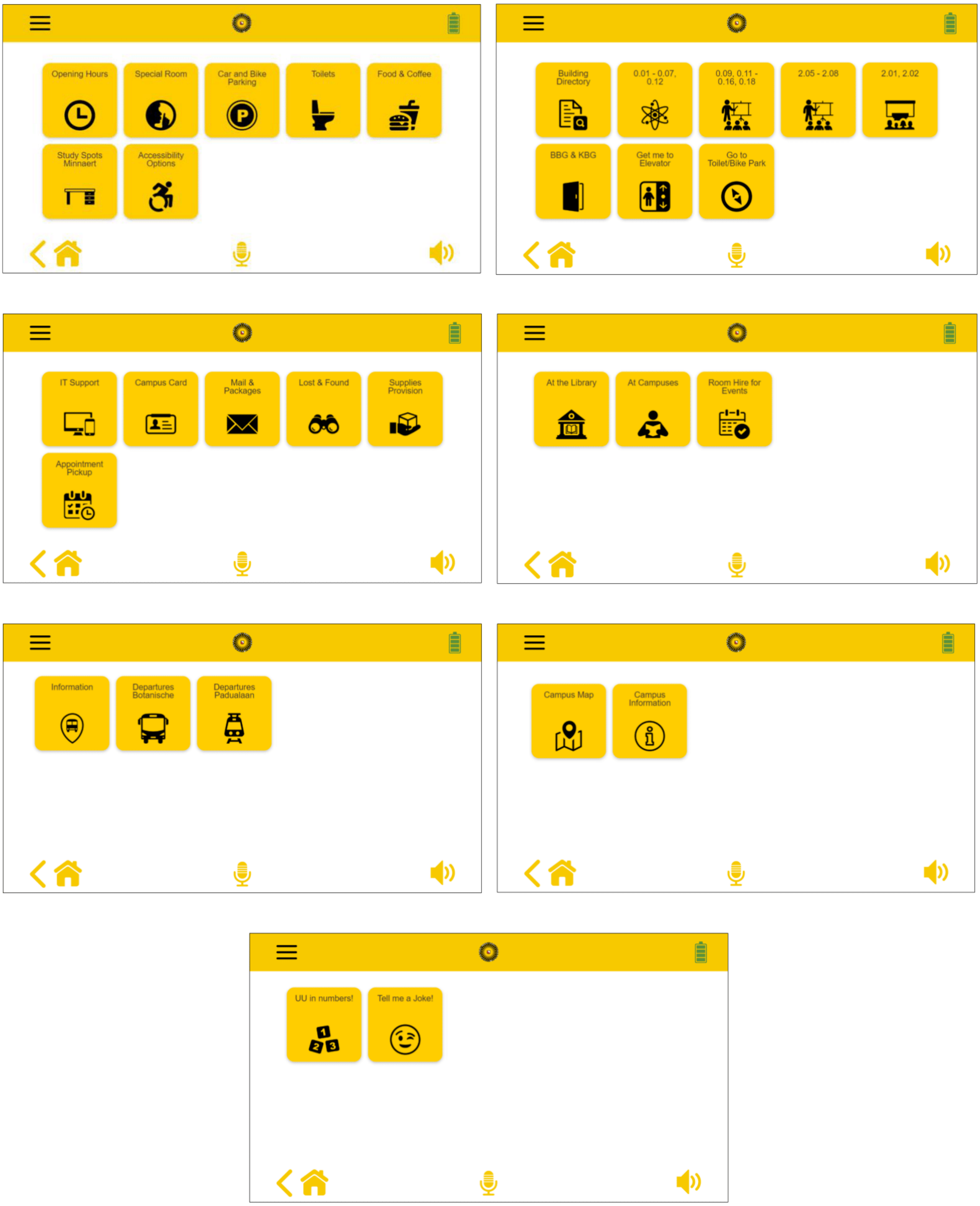
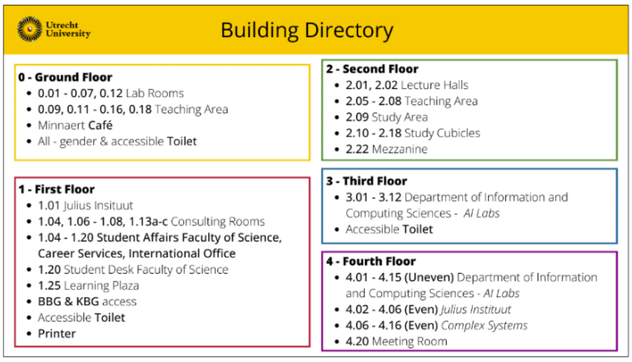
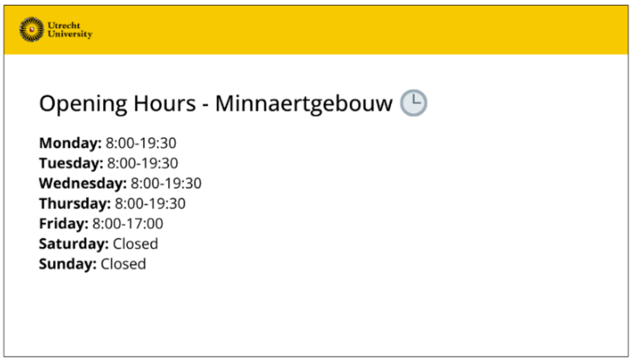
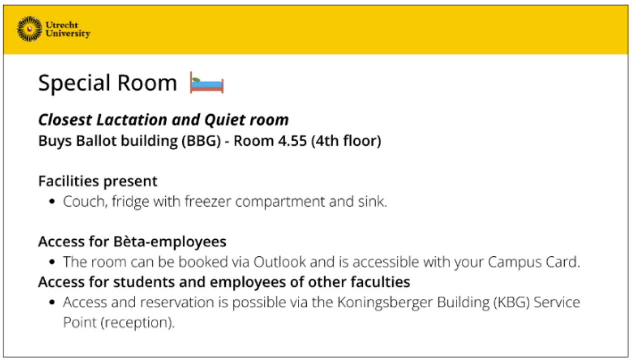
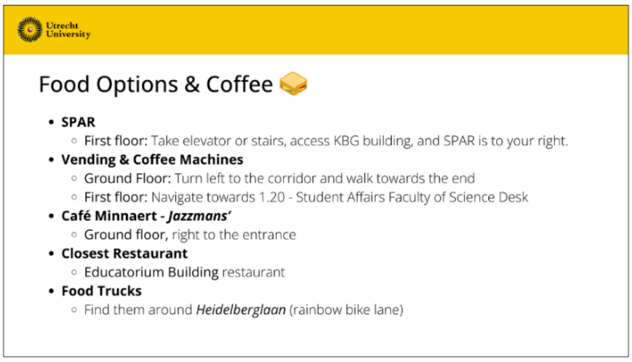


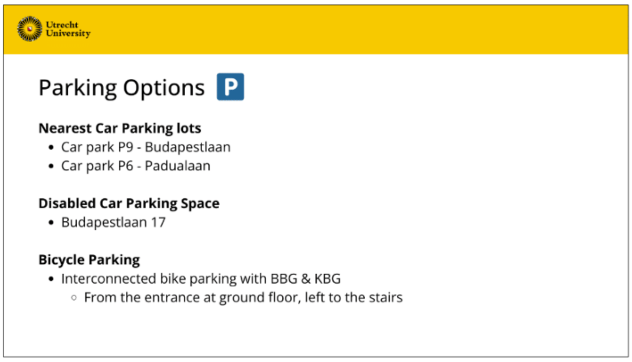
Figure 12: Kiosk Interfaces - Folder Components

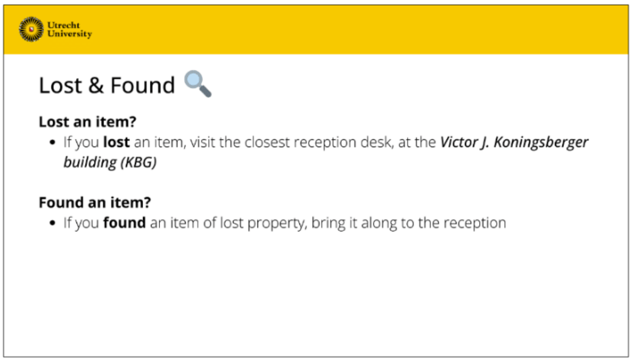


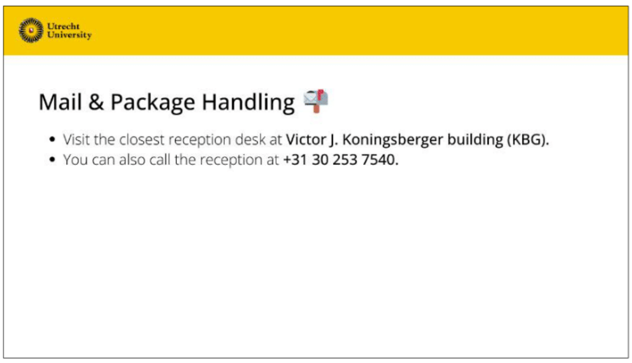












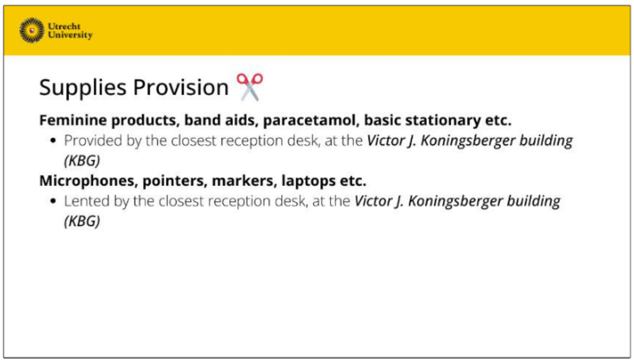
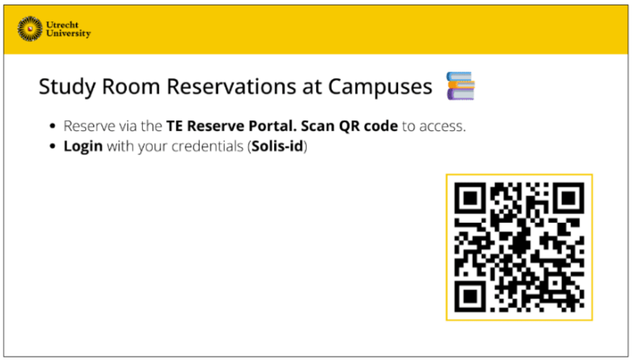
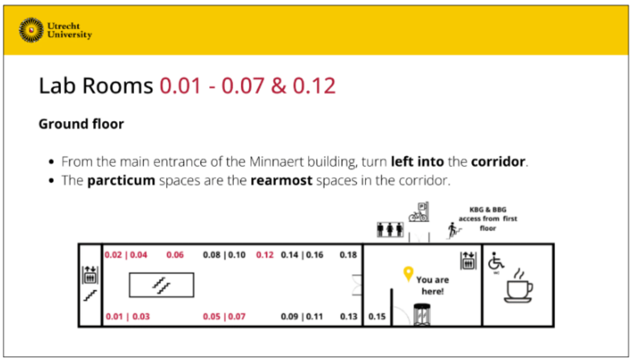
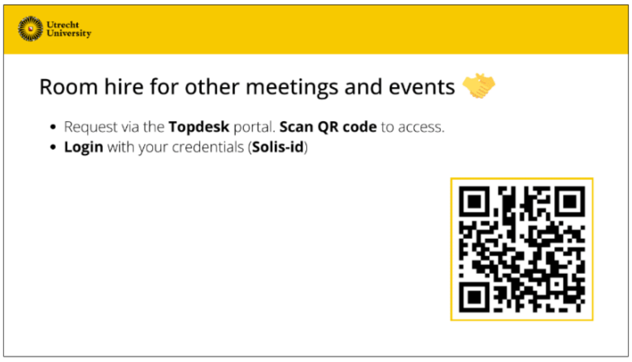
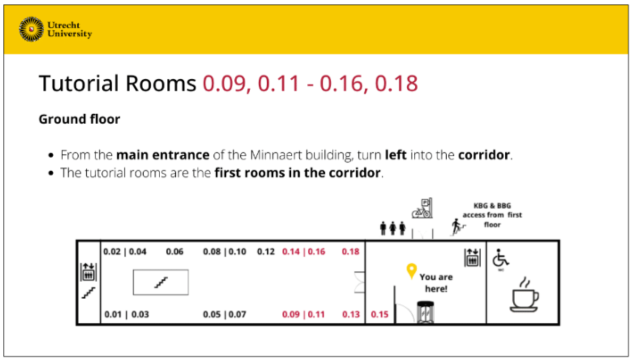


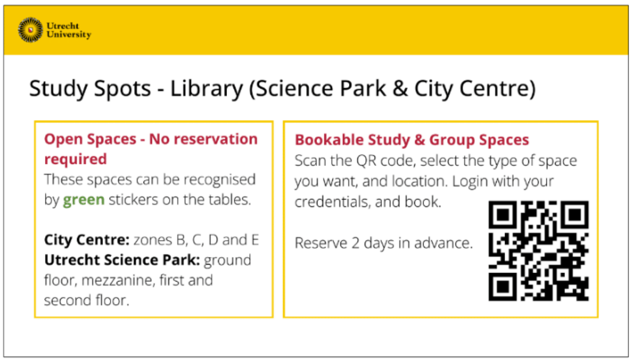
Figure 13: Interfaces (1)

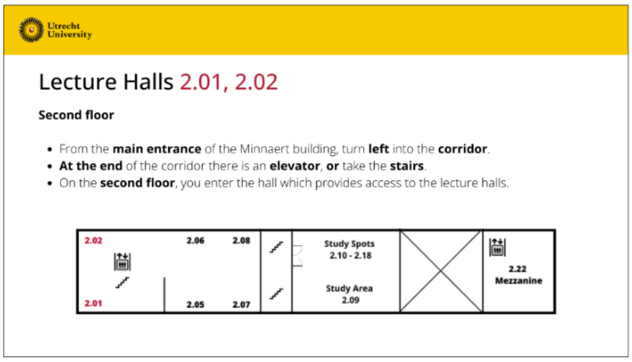


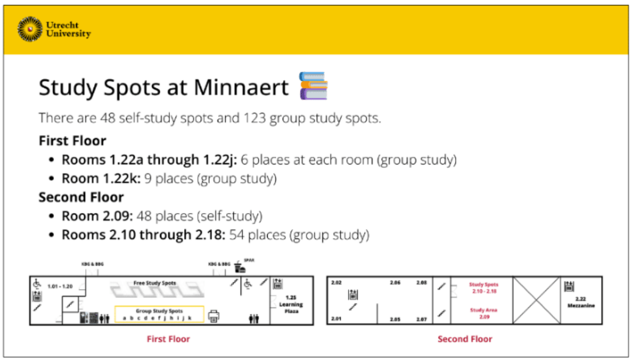












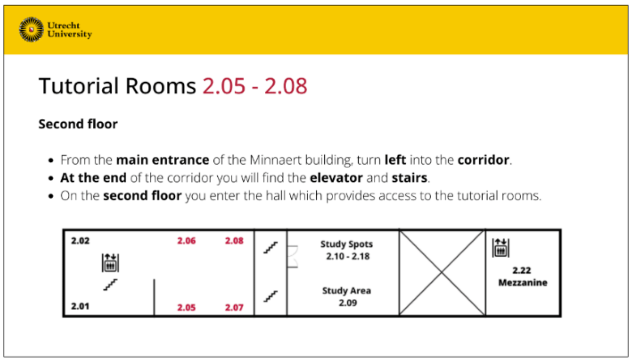


Figure 14: Interfaces (2)

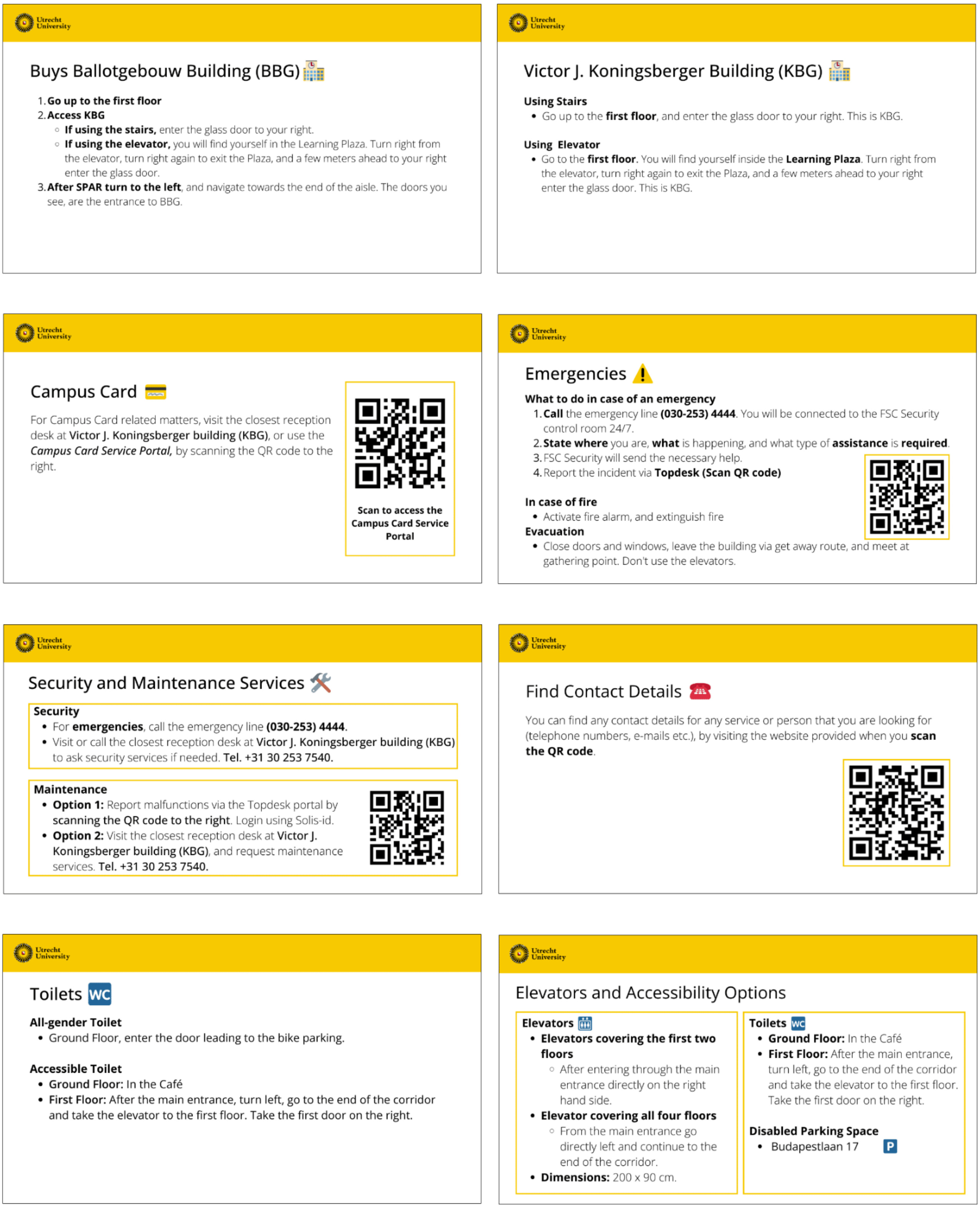


Figure 15: Interfaces (3)

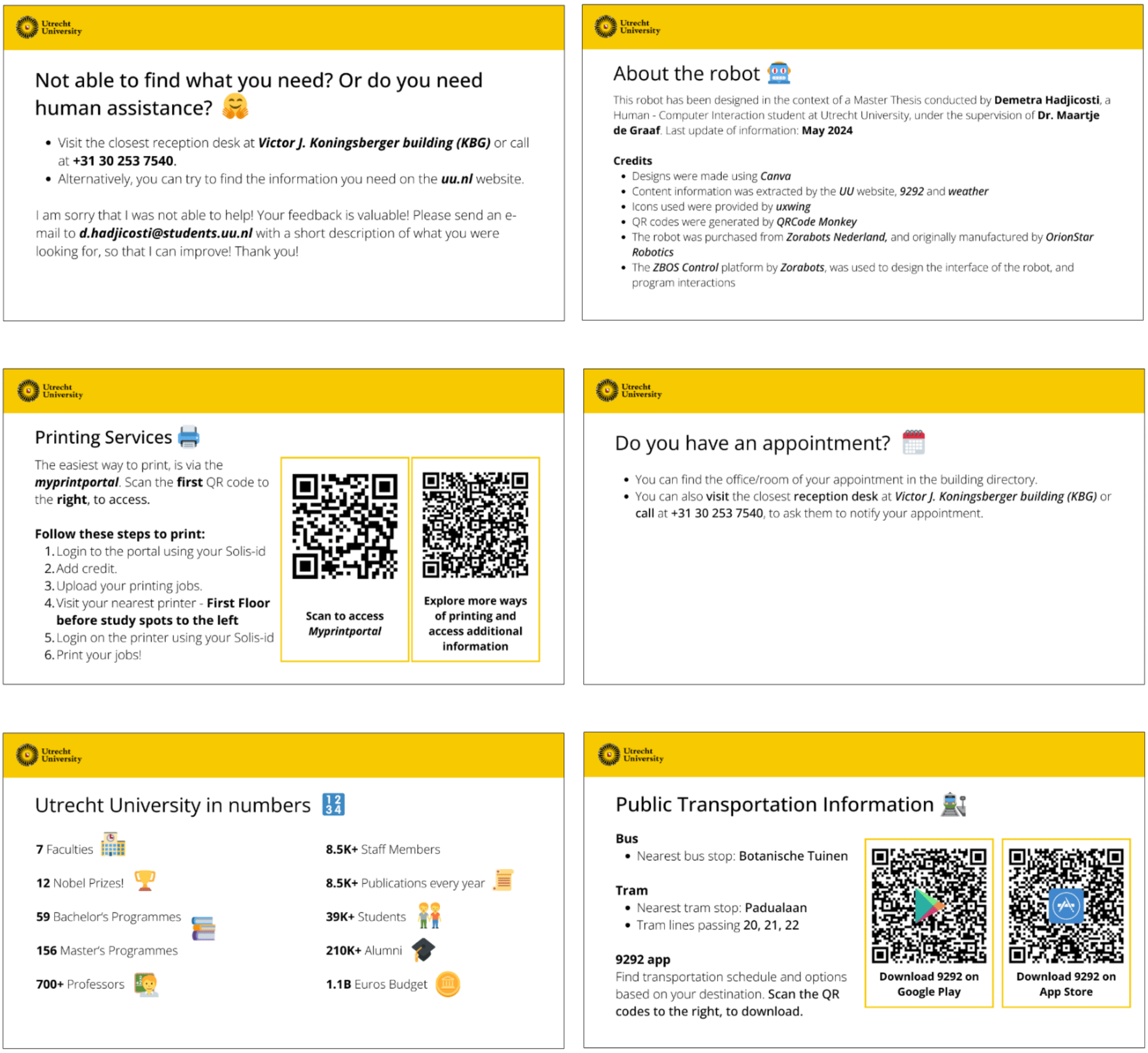


Figure 16: Interfaces (4)

C User Testing - Evaluation

C.1 Information Sheet and Consent Form

Universiteit Utrecht

Research Participant Information Sheet – User Testing

An Alternative Welcome: Exploring the Integration of Robots in University Receptions

14 - 24/05/2024

1. Introduction

You are kindly requested to take part in a User Testing conducted for the purposes of gathering data in the context of a Master Thesis scientific research project in the field of Human-Computer Interaction with title ***"An Alternative Welcome: Exploring the Integration of Robots in University Receptions"***. The User Testing sessions will be conducted in the *Minnaertgebouw* building entrance at *Utrecht University*.

2. What is the background and purpose of this study?

The main goal of this research project is exploring the integration of robots into university receptions, in locations without a reception desk. The general aim is to contribute to the field of Human-Robot Interaction. The User Testing is part of the Evaluation part of the research, where the purpose is to gather insights about the final design of the robot that was built based on Requirements Analysis that took place earlier this year. The results of the User Testing sessions will be the basis on which design recommendations for similar robots are developed.

3. Who will carry out the study?

This study is carried out by **Demetra Hadjicosti** (d.hadjicosti@students.uu.nl) as part of a master thesis under supervision of **Maartje De Graaf** (m.m.a.degraaf@uu.nl).

4. How will the study be carried out?

In this study, you will have a short interaction for 5 to 10 minutes with a reception robot. During your interaction with the robot, the researcher will observe you and take some systematic notes. After finishing with the interaction, you will fill out a survey that contains some basic demographic questions, a few Likert scale questions, and 3 open-ended questions about your opinions regarding the robot. Filling out the survey will approximately take 5 minutes. In total, the study will take about 10-15 minutes. You will get some snacks at the end, as a compensation for your participation.

5. What will we do with your data?

We will securely store the data you provide, namely your age, occupation, gender, your ratings, and opinions about the robot.

6. What are your rights?

Participation is voluntary. We are only allowed to collect your data for our study if you consent to this. If you decide not to participate, you do not have to take any further action. You do not need to sign anything. Nor are you required to explain why you do not want to participate. If you decide to participate, you can always change your mind and stop participating at any time, including during the study. You will even be able to withdraw your consent after you have participated. However, if you choose to do so, we will not be required to undo the processing of your data that has taken place up until that time. The personal data we have obtained from you up until the time when you withdraw your consent will be erased (where personal data is any data that can be linked to you, so this excludes any already anonymized data).

Page 1 of 2

Universiteit Utrecht

7. Approval of this study

This study has been allowed to proceed by the Research Institute of Information and Computing Sciences on the basis of an Ethics and Privacy Quick Scan. If you have a complaint about the way this study is carried out, please send an email to: ics-ethics@uu.nl. If you have any complaints or questions about the processing of personal data, please send an email to the Faculty of Sciences Privacy Officer: privacy-beta@uu.nl. The Privacy Officer will also be able to assist you in exercising the rights you have under the GDPR. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information at www.uu.nl/en/organisation/privacy.

8. More information about this study?

If you have any questions or concerns about this research, please contact Demetra Hadjicosti at d.hadjicosti@students.uu.nl

9. Appendices:

- Consent Form found within the online survey

Page 2 of 2

Figure 17: User Testing - Information Sheet (1) & (2)

Universiteit Utrecht

Online Consent form for participation in the research project
"An Alternative Welcome: Exploring the Integration of Robots in University Receptions"

Please read the statements below and tick the final box to confirm you have read and understood the statements and upon doing so agree to participate in the project.

- I confirm that I am 18 years of age or over.
- I confirm that the research project "An Alternative Welcome: Exploring the Integration of Robots in University Receptions" has been explained to me. I have had the option to ask questions about the project and have had these answered satisfactorily. I can reach out for questions whenever I want. I had enough time to consider whether to participate.
- I consent to the material I contribute being used to generate insights for the research project "An Alternative Welcome: Exploring the Integration of Robots in University Receptions".
- I understand that personal data will be collected from me, and that this information will be held confidentially so that Demetra Hadjicosti has access to this data and are able to trace the information back to me personally. The information will be held in the researcher's secure personal University drive for up to 3 months after which period if will be fully anonymised. In accordance with the General Data Protection Regulation (GDPR) I can have access to my information and can request my data to be deleted at any time during this period.
- I understand that my participation in this research is voluntary and that I may withdraw from the study at any time without providing a reason, and that if I withdraw any personal data already collected from me will be erased.
- I consent to allow the fully anonymized data to be used in future publications and other scholarly means of disseminating the findings from the research project.
- I understand that the data acquired will be securely stored by researchers, but that appropriately anonymized data may in future be made available to others for research purposes. I understand that the University may publish appropriately anonymized data in appropriate data repositories for verification purposes and to make it accessible to researchers and other research users.
- I understand that I can request any personal data collected from me to be deleted.

☐ **I confirm that I have read and understood the above statements and agree to participate in the study.**

Figure 18: User Testing - Consent Form

C.2 Poster

Figure 19: Experiment Poster

D Final Requirements Specification

Information Provision Requirements

1. **Public Transportation Information**
   - Information about nearby public transportation options and live departures.
2. **Event Information**
   - Information about events organized at the University.
3. **Weather Information**
   - Live local weather information.
4. **Lost and Found Information**
   - Information on how to report lost items and where to find lost ones.
5. **Campus Information and Other Building Information**
   - Information about campus facilities and other buildings within the campus.
6. **Wi-Fi and IT Support**
   - Information about Wi-Fi availability, access, and support with Information Technology issues.
7. **Restrooms, Prayer Rooms, Shop Locations**
   - Locations of restrooms, prayer rooms, and shops within the building.
8. **Printing Services Information**
   - Information about printing services available (in general and within the building).
9. **Food Options and Coffee Machine Information**
   - Information about available food options and coffee machines within the building and campus.
10. **Parking Availability**
    - Information about available parking spaces (both for bikes and cars).
11. **Campus Card Information**
    - Information about campus card.
12. **Building Directory and Faculties, Opening Times, State in which building the robot is at**
    - Directory of the building and present faculties, opening times, and a clear indication of the robot's current location.

13. **Directions to Rooms - Places**

    - Provides directions to rooms, but only guides close to the reception area. The receptionist should be present near the reception/entrance area at all times.

14. **Mail-related Inquiries and Package Handling**

    - Handle mail-related inquiries or packages or redirect visitors to the closest reception.

15. **Implementation of Friendly Features**

    - Implements friendly features such as telling jokes and providing fun facts.

16. **Emergencies Assistance and Information**

    - Information about emergency handling, and corresponding contact points.

17. **Contact Points and Emails**

    - Provides numbers, emails, and contact points information for university offices, staff and more.

18. **Interactive Campus Map**

    - Provides an interactive map of the campus.

19. **Assistance for Appointments**

    - Assists in picking up appointments.

20. **Assistance in Finding Study Spaces, Room Reservation Support**

    - Assists in finding study spaces and supports room reservations.

21. **Call Security or Maintenance if Needed**

    - Ability to call security or maintenance if required or provide with contact points or redirect to the closest reception.

22. **Interactive Building Map**

    - Include an interactive building map that displays rooms, directions, and points of interest.

23. **Supply Visitors with Stationary, Feminine Products, Coffee Cups, etc.**

    - Can supply visitors with basic stuff or redirect them to the closest reception.

Interface Requirements

1. **Interface: Clear font**
    - User interface with clear and readable fonts.
2. **Interface: Simple app-like design**
    - Simple interface design resembling smartphone apps.
3. **Interface: Intuitive Interface Design**
    - User-friendly interface design that is easy to use.
4. **Interface: Clear, Easy way of information presentation**
    - Communication in clear and easy-to-understand language, simplifying dense and confusing websites. Minimize information overload by utilizing QR codes to provide access to additional material.
5. **Interface: Volume control**
    - Ability to adjust the volume of the robot on screen.
6. **Interface: Discrete, Welcoming, and Kind Robot**
    - Robot behaves in a discreet, welcoming, and friendly manner.
7. **Interface: Interact on demand**
    - Ability to detect and interact with users when they approach.
8. **Interface: Main Menu**
    - Have a clear menu with big icons representing the features.
9. **Provide Brief Instructions on how the robot works**
    - Display a set of usage instructions directly on the robot, in addition to the Poster.
10. **Give users a list of directions with what they should do when looking for something**
    - Provides in a simple way guidance on actions users should take to fulfill their needs.
11. **Integrate information needed only within the robot's interface**
    - Communicate information within the robot's interface rather than just linking to external websites.

Interaction Requirements

1. **Accessibility for Disabled People**
    - Provides accessibility information and directions for disabled individuals.
2. **Autonomous Movement for Guiding Users**
    - Ability to move autonomously to guide users.
3. **Security Mechanisms/Privacy**
    - Implements security mechanisms to protect user privacy.
4. **Concise Communication and Short Messages**
    - Provides clear and concise communication and messages.
5. **Multi-modal Interaction**
    - Supports interaction via touchscreen, and speech induced interaction.
6. **Visual Cues and Feedback**
    - Provides visual cues and feedback to users.
7. **Greeting Visitors**
    - Greet visitors when they approach or initiate interaction with the robot.
8. **Multiple Modalities of Information Presentation**
    - Presents information using multiple modalities (voice, screen, images etc.).
9. **Voice-controlled Interactions**
    - Supports voice-controlled interactions. Ensure that the robot responds accurately to voice instructions.
10. **High-quality interaction capabilities**
    - Ensure high-quality interaction and reduce response times.
11. **Support Multiple Languages**
    - Enable language choice.
12. **Deploy Multiple Interconnected Robots**
    - Deploy multiple interconnected robots across different floors to cover needs throughout the whole building.

Appearance Requirements

1. **Maintain a face while interacting with users**
    - Robot should carry a face when interacting with users.
2. **Smiley Face Display when Idle**
    - Displays a smiley face when idle.
3. **Clear Indication of Purpose**
    - Clearly indicates its purpose and functions.
4. **Height and Size Adjustments**
    - Height and size of robot which accommodates physical characteristics of visitors.

E Ethics and Privacy Quick Scan

Ethics and Privacy Quick Scan *(version: 31 July 2023)*

Section 1. Research projects involving human participants

		Yes	No
P1	Does your project involve human participants? This includes for example use of observation, (online) surveys, interviews, tests, focus groups, and workshops where human participants provide information or data to inform the research. If you are only using existing data sets or publicly available data (e.g. from Twitter, Reddit) without directly recruiting participants, please answer no.	✓	

Recruitment

		Yes	No
P2	Does your project involve participants younger than 18 years of age?		✓
P3	Does your project involve participants with learning or communication difficulties of a severity that may impact their ability to provide informed consent?[1]		✓
P4	Is your project likely to involve participants engaging in illegal activities?		✓
P5	Does your project involve patients?		✓
P6	Does your project involve participants belonging to a vulnerable[2] group, other than those listed above?		✓
P8	Does your project involve participants with whom you have, or are likely to have, a working or professional relationship: for instance, staff or students of the university, professional colleagues, or clients?	✓	
P9	Is it made clear to potential participants that not participating will in no way impact them (e.g. it will not directly impact their grade in a class)?	✓	

[1] For informed consent people need to be able to (1) understand information provided relevant to making the consent decision, (2) retain this information long enough to be able to make a decision, (3) weigh the information, (4) communicate the decision.
[2] Vulnerable people include those who are legally incompetent, who may have difficulty giving or withholding consent, or who may suffer highly adverse consequences if their personal data were to become publicly available or from participating. Examples include irregular immigrants, sex workers, dissidents and traumatized people at risk of re-traumatization.

Consent Procedures		Yes	No	Not applicable
PC1	Do you have set procedures that you will use for obtaining *informed* consent from all participants, including (where appropriate) parental consent for children or consent from legally authorized representatives? (See suggestions for information sheets and consent forms on the website[3].)	✓		
PC2	Will you tell participants that their participation is voluntary?	✓		
PC3	Will you obtain explicit consent for participation?	✓		
PC4	Will you obtain explicit consent for any sensor readings, eye tracking, photos, audio, and/or video recordings?	✓		
PC5	Will you tell participants that they may withdraw from the research at any time and for any reason?	✓		
PC6	Will you give potential participants time to consider participation?	✓		
PC7	Will you provide participants with an opportunity to ask questions about the research before consenting to take part (e.g. by providing your contact details)?	✓		
PC8	Does your project involve concealment[4] or deliberate misleading of participants?		✓	

Section 2. Data protection, handling, and storage

The General Data Protection Regulation imposes several obligations for the use of **personal data** (defined as any information relating to an identified or identifiable living person) or including the use of personal data in research.

		Yes	No
D1	Are you gathering or using personal data (defined as any information relating to an identified or identifiable living person[5])?	✓	

[3] uu.nl/en/research/institute-of-information-and-computing-sciences/ethics-and-privacy
[4] This may for example involve concealment of the study aim, of the identity of the researcher, or subliminal messaging during the study.
[5] This includes people's name, postal address, unique ID, IP address, voice, photo, video etc. When a person can be identified by combining multiple data points (e.g. gender + age + job role), this also constitutes personal data. When a person can be identified by a simple search online (e.g. with the content of a tweet) this also constitutes personal data. Note that Survey tool Qualtrics by default collects IP addresses and that the survey needs to be anonymized before distribution to prevent this.

Figure 20: Quick Scan (1) and (2)

High-Risk Data

		Yes	No
DR1	Will you process personal data that would jeopardize the physical health or safety of individuals in the event of a personal data breach?		✓
DR2	Will you combine, compare, or match personal data obtained from multiple sources, in a way that exceeds the reasonable expectations of the people whose data it is?[6]		✓
DR3	Will you use any personal data of children or vulnerable individuals for marketing, profiling, automated decision-making, or to offer online services to them?		✓
DR4	Will you profile individuals on a large scale[7]?		✓
DR5	Will you systematically monitor individuals in a publicly accessible area on a large scale[8] (or use the data of such monitoring)?[9]		✓
DR6	Will you use special category[10] personal data, criminal offense personal data, or other sensitive personal data[11] on a large scale?		✓
DR7	Will you determine an individual's access to a product, service, opportunity, or benefit[12] based on an automated decision or special category personal data?		✓
DR8	Will you systematically and extensively monitor or profile individuals, with significant effects[13] on them?		✓
DR9	Will you use innovative technology[14] to process sensitive personal data[15]?		✓

[6] This is about the combined use of data sets that have been gathered for different purposes (so not within one study), making the data more personal or sensitive. For example, combining participant data with religion or ethnic statistics data from the CBS based on zip code.
[7] Large scale is for example thousands of people, all visitors to a university website, data obtained over a very large time span
[8] Large scale is for example thousands of people, all visitors to the area, data obtained over a very large time span
[9] This may also include camera surveillance and use of drones
[10] Special category personal data is information about a person's health, ethnic origin, politics, religion, trade union membership, genetics, biometrics (where used in identification), sex life or sexual orientation.
[11] Other sensitive personal data includes for instance financial data (from which people's income, capital position or spending patterns can be derived), location data (from which people's movement patterns can be derived), achievement data (e.g. outcome of course work/exams, intelligence test; this excludes performance on tasks in a research study that are unrelated to their study/job), and communication data.
[12] Examples include: access to a mortgage, insurance, credit card, smartphone contract, course or degree programme, job opportunity.
[13] Significant effects are for example impacts on somebody's legal rights, automatic refusal of a credit application, automatic rejection for a job application.
[14] Innovative technology includes e.g. machine learning (including deep learning), neuro measurement (e.g. brain activity), autonomous vehicles, deep fakes, wearables, blockchain, internet of things.
[15] Sensitive personal data includes all data mentioned in DR6.

Data Minimization

		Yes	No
DM1	Will you collect only personal data that is strictly necessary for the research?	✓	
DM4	Will you anonymize the data wherever possible?[16]	✓	
DM5	Will you pseudonymize the data if you are not able to anonymize it, replacing personal details with an identifier, and keeping the key separate from the data set?	✓	

Using Collaborators or Contractors that Process Personal Data Securely

		Yes	No
DC1	Will any organization external to Utrecht University be involved in processing personal data (e.g. for transcription, data analysis, data storage)?[17]		✓

International Personal Data Transfers

		Yes	No
DI1	Will any personal data be transferred to another country (including to research collaborators in a joint project)?		✓

Fair Usage of Personal Data to Recruit Participants

		Yes	No
DF1	Is personal data used to recruit participants?[18]		✓

Participants' data rights and privacy information

		Yes	No	Not Applicable
DP1	Will participants be provided with privacy information? (Recommended is to use as part of the information sheet: For details of our legal basis for using personal data and the rights you have over your data please see the	✓		

[16] Possible also means given the research question. So, for example, if you have done interviews and you need to be able to at a later date link them to performance data, it is impossible to anonymize the interviews, and you will need to pseudonymize them. You can then answer yes to DM4 as you are anonymizing where it is possible, and yes to DM5 if indeed you pseudonymize. Note that in such a case you should anonymize once the linking has been done, destroying the key that links the pseudonym to the identity of the participant.
[17] You can answer No if this is only the use of online software, as long as this software has been deemed safe by Utrecht University. See https://tools.uu.nl/tooladvisor/ for tools that are safe/not safe to use (e.g. Microsoft Word Online Transcribe is fine, NVivo Transcription is not).
[18] Intended here is the direct use of personal data to target a specific person. If you are using personal data indirectly to address a group of people, for example, sending a message via a *pre-existing* Microsoft Team, Blackboard course, Discord Channel, WhatsApp group, or crowd-sourcing platform, that is fine and will not be regarded as the use of personal data here. If you are asking friends or family members this will also not be regarded as use of personal data here.

Figure 21: Quick Scan (3) and (4)

	University's privacy information at www.uu.nl/en/organisation/privacy.)			
DP2	Will participants be aware of what their data is used for?	✓		
DP3	Can participants request that their personal data be deleted?[19]	✓		
DP4	Can participants request that their personal data be rectified (in case it is incorrect)?[24]	✓		
DP5	Can participants request access to their personal data?[24]	✓		
DP6	Can participants request that personal data processing is restricted?	✓		
DP7	Will participants be subjected to automated decision-making based on their personal data with an impact on them beyond the research study to which they consented?		✓	
DP8	Will participants be aware of how long their data is being kept for, who it is being shared with, and any safeguards that apply in case of international sharing?	✓		
DP9	If data is provided by a third party, are people whose data is in the data set provided with (1) the privacy information and (2) what categories of data you will use?			✓

Using data you have not gathered directly from participants

		Yes	No
DE1	Will you use any personal data[20] that you have not gathered directly from participants (such as data from an existing data set, data gathered by a third party, data scraped from the internet)?		✓

Secure data storage

		Yes	No
DS1	Will any data be stored (temporarily or permanently) anywhere other than on password-protected University authorized computers or servers?[21]		✓

[19] This only concerns requests for personal data that you still hold. If you can no longer link the data to a participant due to anonymization, you can no longer delete, rectify or provide access to it. This should be clear to participants in the consent form. If the data is pseudonymized and you cannot access the key but the participant can (for example when the key is a WorkerID from a crowd-sourcing platform), participants should be able to request deletion on the provision of the key.

[20] Defined as any data related to an identified or identifiable living person. This includes people's name, postal address, unique ID, IP address, voice, photo, video etc. When a person can be identified by combining multiple data points (e.g. gender + age + job role), this also constitutes personal data.

[21] OneDrive business, Qualtrics, Microsoft Forms are ok. Do not use Google Drive/Sheets/Docs/Forms, Dropbox, OneDrive personal. See https://tools.uu.nl/tooladvisor/ for tools that are safe/not safe to use. Bachelor and master students are authorized to use a password-protected personal computer, as long as that computer is not shared with other people.

		Yes	No
DS4	Excluding (1) any international data transfers mentioned above and (2) any sharing of data with collaborators and contractors, will any personal data be stored, collected, or accessed from outside the EU[22]?		✓

Section 3: Research that may cause harm

Research may harm participants, researchers, the university, or society. This includes when technology has dual-use, and you investigate an innocent use, but your results could be used by others in a harmful way. If you are unsure regarding possible harm to the university or society, please discuss your concerns with the Research Support Office.

		Yes	No
H1	Does your project give rise to a realistic risk to the national security of any country?[23]		✓
H2	Does your project give rise to a realistic risk of aiding human rights abuses in any country?[24]		✓
H3	Does your project (and its data) give rise to a realistic risk of damaging the University's reputation? (E.g., bad press coverage, public protest.)		✓
H4	Does your project (and in particular its data) give rise to an increased risk of attack (cyber- or otherwise) against the University? (E.g., from pressure groups.)		✓
H5	Is the data likely to contain material that is indecent, offensive, defamatory, threatening, discriminatory, or extremist?		✓
H6	Does your project give rise to a realistic risk of harm to the researchers?[25]		✓
H7	Is there a realistic risk of any participant experiencing physical or psychological harm or discomfort?[26]		✓
H8	Is there a realistic risk of any participant experiencing a detriment to their interests as a result of participation?		✓
H9	Is there a realistic risk of other types of negative externalities?[27]		✓

[22] This may happen, for instance, when data is collected and stored on a Utrecht University laptop whilst abroad.

[23] For example, research that can be used for autonomous armed vehicles/drones/robots, research on automated detection of objects, research on AI-enhanced forgery of video/audio data.

[24] For example, research on natural language/video/audio processing for automated identification of people's identity, sentiments, or opinions.

[25] For example, research that involves potentially violent participants such as criminals, research in likely unsafe locations such as war zones, research on an emotionally highly challenging topic, research in which the researcher is alone with a not previously known participant in the participant's home.

[26] For example, research that involves strenuous physical activity, research that stresses participants, research on an emotionally challenging topic.

[27] A negative externality is a harm produced to a third party, society in general, or the environment. For instance, intended or unintended negative ethical (e.g. bad governance or management practices), social (e.g. consumerism, inequality) or environmental effects (e.g. large CO2 footprint or e-waste production) of your project.

Figure 22: Quick Scan (5) and (6)

Section 4: Conflicts of interest

		Yes	No
C1	Is there any potential conflict of interest (e.g. between research funder and researchers or participants and researchers) that may potentially affect the research outcome or the dissemination of research findings?		✓
C2	Is there a direct hierarchical relationship between researchers and participants?		✓

Section 5: Your information

This last section collects data about you and your project so that we can register that you completed the Ethics and Privacy Quick Scan, sent you (and your supervisor) the summary of what you filled out, and follow up where a fuller ethics review and/or privacy assessment is needed. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information. Please see the guidance on the ICS Ethics and Privacy website on what happens on submission.

Z0. Which is your main department?

- • Information and Computing Science
- ○ Freudenthal Institute
- ○ Pharmacy
- ○ Other, namely:

Z1. Your full name: **Demetra Hadjicosti**

Z2. Your email address: **d.hadjicosti@students.uu.nl**

Z3. In what context will you conduct this research?

- ○ 1. As a student on a course with course coordinator:
- ○ 2. As a student for my bachelor thesis, supervised by:
- • 3. As a student for my master thesis, supervised by:
- ○ 4. As a PhD student, supervised by:
- ○ 5. As an independent researcher (e.g. research fellow, assistant/associate/full professor)

Z5. Master programme for which you are doing the thesis:

- ○ Applied Data Science
- ○ Artificial Intelligence
- ○ Business Informatics
- ○ Computing Science
- ○ Data Science
- ○ Game and Media Technology
- • Human-Computer Interaction
- ○ Other:

Z6. Email of the course coordinator or supervisor (so that we can inform them that you filled this out and provide them with a summary):

m.m.a.degraaf@uu.nl

Z7. Email of the moderator (as provided by the coordinator of your thesis project):

graduation.hci@uu.nl

Z8. Title of the research project/study for which you filled out this Quick Scan:

An Alternative Welcome: Exploring the Integration of Robots in University Receptions

Z9. Summary of what you intend to investigate and how you will investigate this (200 words max):

This study explores integrating robots into Utrecht University's receptions, whether in locations without a desk or as additional aids where receptions already exist. Using a bottom-up approach, it begins with requirements analysis with naturalistic observation of the buildings' entrance environments, interviews with current receptionists, and focus groups with future users. Then, it implements on the Zorabots Mini robot, and concludes with evaluation of the implemented interaction. Ultimately, this research aims to provide design recommendations for future robot implementations in university settings, addressing the functional needs of users.

		Yes	No	Not Applicable
Z10.	In case you encountered warnings in the survey, does your supervisor already have ethical approval for a research line that fully covers your project?			✓

Z11. Provide details on the ethical approval (e.g. ethical approval number):

-

Figure 23: Quick Scan (7) and (8)