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SOCIAL ROBOTS AS CHANGE AGENTS WITH THE ROLE OF MEDIATORS IN HUMAN-HUMAN COMMUNICATION

A Study for Social Engagement in University Campus Environment

Master's Thesis
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ABSTRACT

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Robots have been a part of our lives already for some time. Especially with the developing technology and new developments in robotics, there is an increasing number of application areas. For example, construction, health care, transportation, agriculture and entertainment etc. While these are mostly industrial robots, social robotics as a separate field is becoming more and more popular with increasing number of social robots being introduced. As the role of technologies in our lives is becoming even more vital with developments in machine learning, artificial intelligence (AI), and robotics, potential of social robotics is also growing. Being a part of our lives, socially interactive robots with embodied design already support humans in many activities and scenarios. Thanks to their embodied design, abilities and the constantly developing technology behind these, social robots have a great potential of participating in social life of humans by understanding, sharing, and responding.

While there is an ongoing debate on robot's involvement in our lives, the transition and our adaptation towards a social form where humans and robots co-exist continues. In this thesis, we therefore investigate social robots with a question whether they can have the role for mediating human-human communication and enhance social engagement. For this, we look at the university campus setting. In order to answer the research questions, we aim to identify scenarios on how social robots could be used in social context at university campuses with a focus on social engagement.

In order to identify the design considerations and use cases for such robots, we conducted a pre-study with interviews with 16 participants. These revealed the following focus areas design considerations: ease of access, mobility, humanness, simplicity, and user-friendliness. Based on these design considerations and previous research in the field, we developed and introduced three concepts for social robots in university campus environment with a focus on enhancing social engagement and connectedness. In each concept we provided a design for socially interactive robots with different design metaphors, role, and forms. We later conducted a user evaluation questionnaire with 10 participants using the Robot Attitude Scale (RAS) and interviews. Overall, the results showed that all concepts were found to be attractive and participants accepted the design recognizing their potential to mediate the social connectedness and communication. Also, the effect of embodiment on user's perception and approach towards social robots was found to be positive. Additionally, there were new scenarios and use cases suggested by participants during the evaluation phase which can be consider in future research.

Based on the previous work in the field, the results from pre-study and user evaluation in this thesis, we gathered five design implications which emphasise: matching robot's role and tasks with its design, naturalness of human-robot interaction by design, embodiment for user involvement, readable social cues for engaging design, and making interaction accessible with mobile design. These apply to social robots which can act as mediators in human-human communication and connectedness. A future research on this topic would be beneficial to design concepts and social robots with these design considerations to be further evaluated with physical prototypes and face-to-face interviews with actual users under a separate study. We believe, social robots with such embodied design attributes and social roles can attract people to engage with first the robots and through the robots connect and engage with the rest of society.

Keywords: social robots, social engagement, embodiment, social connectedness, human-robot interaction.

The originality of this thesis has been checked using the Turnitin OriginalityCheck service.

PREFACE

Studying User Experience and learning about Human Technology Interaction has been an invaluable experience and an interesting journey for me. Being a technology lover, I always strived to learn more and understand the underlying elements of technology design. Additionally, I find the recent developments in artificial intelligence (AI) and social robotics exiting. Especially considering the UX design and its importance on how it affects the way we perceive things, there still remains great amounts to discover and learn. Also, considering the potential and the role of ground-breaking inventions such as socially interactive embodied robots requires a lot of research and thinking. Therefore, I am fortunate and grateful for having the opportunity to have conducted the thesis work on this topic.

I would like to express my sincere gratitude to my supervisor Dr. Kirsikka Kaipainen who has supported and guided me throughout this thesis work. I am grateful and happy to have worked with her.

I also would like to thank to all my friends and colleagues who have been supportive and patient during my thesis journey. Their kind support will always be remembered.

Lastly, for her unconditional love and support, I would like to thank my mom. Thanks for always being there and for making all this happen.

Tampere, 30 November 2020

Hakki Meseci

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LIST OF SYMBOLS AND ABBREVIATIONS

RAS	Robot Attitude Scale
HRI	Human-Robot Interaction
HCI	Human-Computer Interaction
HTI	Human-Technology Interaction
URL	Uniform Resource Locator
I-PEFiC	Interactively Perceiving and Experiencing Fictional Character
AI	Artificial Intelligence
IoT	Internet of Things
WHO	World Health Organization
ICT	Information and Computer Technology

1. INTRODUCTION

We are living in an era where technological advancements have the potential of breaking grounds even more than before. With these advancements, limits of our ideas and abilities have also expanded similarly. Nowadays, we talk about smart environments, AI-controlled and autonomous vehicles, and social robots as a part of our daily life. As a consequence of the changes we experience, the need for social consideration becomes more and more important. The way we adapt to new technologies influence our habits and behaviour. As a result, our social environment is reshaped and redefined over time. Failing to adapt to changes, us, humans, and our society are in need of solutions and plan of actions which could serve our social wellbeing continuously today and in the future.

In this thesis, we look at the ways our social activities and interactions can be supported and facilitated by technology, specifically by socially interactive robots with a special emphasis on the university campus environment. In international environments such as university campuses there take place various interactions between people from different origins and groups (staff, academics, students, visitors etc.). In terms of the way these interactions happen between campus residents, the environment itself can make the flow complex. In other words, the environment and communication flow could be complicated due to the differences between the interests and actions of these groups in the campus setting. For example, students from a specific degree or class might not meet or get to know each other until they meet in an event. Similarly, students or staff working at the campus (including academics and actual staff) might not know where they can find information on events, gatherings, clubs, activities, and other happenings that they can benefit from. As a result, social connectedness and engagement between these parties fail to reach a satisfying level.

Social robots have a great potential of being medium for communication in public settings. Health care, education, and entertainment are some of the common social robot domains. The characteristics of domains, publicity of spaces, and general conditions that might affect users in general are determinants of how social robots could serve in a specific domain. In other words, the setting of the environments whether they are public, semi-public or private can determine the way social robots can operate and be used.

Although, in terms of accessibility and openness, classrooms (education) and hospitals (healthcare) might not be considered as entirely public, previous research and studies show that social robots could still be used ways beneficial to the society. Among many examples of social robots in public spaces, Pepper in education, Paro and Nao in healthcare, and Robovie in entertainment or other domains are the ones which have been successfully utilized over the past decade. Therefore, we look at the opportunities that socially interactive robots can provide to the society; and in our case to the university campus crowd.

According to the World Health Organization (WHO) social participation is classified as social determinant of health [26]. In the literature, social participation has been used interchangeably with social engagement. Social participation refers to interactions with close contacts (informal) and community organizations (formal) via in-person visits. Social engagement, on the other hand, is about maintaining social connections and participating in social activities [27, 28]. Previous research on these topics show that technology can enhance social participation and mitigate social isolation. Although these studies mainly focused on how older people perceive social participation, results suggest that technology in general can influence social opportunities [27, 28, 29]. For example, results of the study conducted by Kim et al. [27] access to information and communication technology (ICT) and use are associated with their social participation and that there are greater opportunities to promoting active social engagement through ICT. Similarly, in another study [29] we see that technology can enhance the social connectedness and thus the social engagement. Since the term “technology” is rather broad here, it is worth mentioning that we include and refer to various means of ICT such as: e-mail, social media and networking sites, smart phones and tables with voice and video features, computers, smart screens, and other smart devices.

In today’s world we use sustainability to refer to general capacity of biosphere. We can expand this by adding the ability of maintaining a certain level of co-existing in the environments we create; considering the social, environmental, and technological aspects of the world we are living in. Once we include these in the equation, the need for studying social aspects of sustainability become crucial. Especially, considering that humans are social beings, any technological change that affects our lives would require a closer look on how these are socially observed.

Maintaining an ecosystem where the aim is to meet the needs of today and tomorrow, engagement of all members in a society is required. Since sustainability has been considered as the key to a better future with good living environments for all generations, sustainable development is drawing the attention of governments, academics, and our

society in general. In essence, sustainable development is about ensuring human development goals are achieved and needs are met in ecosystems connected to economic, social and natural systems, with the future being a common concern. Sustainability is defined as the quality of being able to continue over a period of time [1]. This definition can be altered to many depending on the context. In line with the social participation and engagement definition, for our study sustainability is taken into consideration for continuity and quality of our social engagement.

According to some sources, the word robot originally refers to “labour” [4, 5]. Indeed, when they joined among us, they joined the work force by slowly replacing the factory personnel since they were found to be much more productive, efficient and durable. However, as Mori (1970) explains in his essay, these robots that replaces humans did not look like humans. In fact, although they imitate movements, industrial robots are far from looking like humans still in our day. Furthermore, based on the nonlinear relationship between affinity and human likeliness in design (The Uncanny Valley [17, 18]) there are important implications to be taken into consideration when designing socially present and interactive robots.

Considering the design of socially interactive robots, in line with Mori’s study [17, 18], it is critical for those to be able to engage in effective social interactions, since these robots are interacting with users primarily through non-physical ways. Embodiment, as a fundamental concept studied in multiple disciplines, provides the opportunity to develop more channels for communication. According to Deng, Mutlu, and Mataric [20] embodiment is a necessity for robots that are in physical and non-physical interaction, although the benefits might be less obvious in virtual presence. Furthermore, in a study where the *embodiment hypothesis* [21] was tested, based on the results physically embodied interactions were found to be more favourable.

There is good amount research previously done on the topic focusing on design aspects of socially interactive robots (social robots as we refer in this study). These, however, deals with different design elements and attributes such as: facial cues, visual speech, virtual presence, face-to-face and virtual interaction etc. [19, 21, 22, 23, 24, 25] Although these could be considered as topics directly or indirectly related to user experience and user experience design, there remains a need for further research in order to determine what the actual user’s prefer in design, communication, and interaction in general.

1.1 Background and motivation

As a part of ongoing research at Tampere University, there is a project investigating how social robots can be designed to motivate and facilitate youth in civic participation in the domain of sustainable development. Project provides a promising niche for this thesis work as it aims to create new scientific knowledge about interaction models of persuasive social robots that can motivate youth (18-24 years) for civic engagement. By conducting an empirical study at university campus environment with students and university employees (academic staff, management, etc.) this thesis work aim at contributing to the ongoing research, which will help youth become socially more active and support designers in creating acceptable designs in the future society populated with social robots.

Research in developing technology in the area of robots and their part in the social environments is a promising one. Therefore, this study itself is a great opportunity to have a closer look on the topic and contribute to today and tomorrow of society where social robots act as change agents encouraging university campus residents towards social participation. Especially the ability to facilitate human-technology interaction in this area and working on identifying ways to use social robots in context of human-human communication pose a great motivation.

1.2 Research objective and questions

The main objective of this study is to develop a conceptual design for a social robot that will take the role of mediators in human-human communication. In this thesis, we will consider communication of student-student, and student-staff.

We will be mainly focusing on the following research questions:

RQ1: How can social robots be used as social mediators of communication at university campus?

This first question is rather broad and therefore will be studied with a set of more specific sub-questions such as:

- What are the areas students and university management can benefit from social robots in communication from social engagement aspect?
- What are the attributes of design that can help achieving social engagement?

RQ2: How can communication and social engagement be enhanced using social robots?

RQ3: What makes the social robot and interaction design attractive for constructive communication?

In order to answer these questions, overall goals of the thesis can be listed as follows:

- Identify scenarios about how social robots could be used in social context at university campuses with a focus on social engagement
- Develop concepts for a communication model where social robots are used as mediators
- Conduct user evaluations for the concepts with target audience

1.3 Research process and methodology

In this thesis work in order to answer the research questions and reach the goals mentioned in the previous section, we use both qualitative and quantitative data and research methods. Qualitative methods used in our study include: pre-study interviews, observations, and thematic content analysis [14, 15, 16] that focused on the collected qualitative data. The quantitative data was gathered using the Robot Attitude Scale (RAS) [35, 36]. Combined with a questionnaire, RAS generated quantitative data based on 12 attributes using an eight-point scale. Accordingly, all collected data and results were analysed qualitatively and quantitatively.

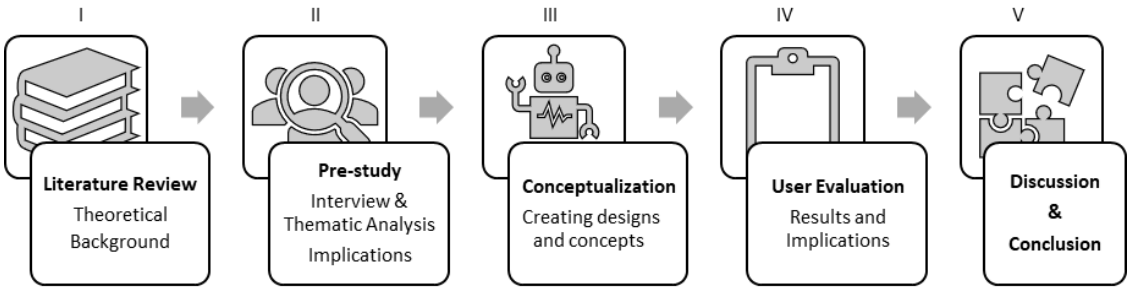

Figure 1. *Research process and main steps*

As illustrated in the Figure 1 above, the research process consists of five main steps. According to this, we start our study with a literature review and providing a theoretical background on the focused topics. In the second step, interviews, interview results and thematic analysis based on these are provided. The results are used to reach design implications and gain insights on the user experience goals for conceptualization purposes. In step three, concepts and designs are created based on the findings and observations in the earlier steps. Next, in step four, user evaluations are conducted for these concepts and designs. In step five, we discuss the results of the user evaluation round, as well as other findings of our study. Finally, we summarize and wrap up the thesis work with a conclusion section.

1.4 Thesis structure

The thesis starts with an introduction where the context of our research is summarized with background information on the covered topics. Next, in Chapter 2, we present related work in the areas such as social robots, social participant and engagement, and design aspects such as embodiment with user experience consideration. Also, recent trends on how social robots are used in common spaces will be presented. These are also handled in Chapter 2.

In Chapter 3, process of the user research is presented in detailed. Applied methodology, results of early interviews, surveys and data collection are provided in this section. Additionally, initial design implications based on the gather data is discussed at the end of the chapter.

In Chapter 4, development process of the concepts is given in detail. First the concept development based on early findings is presented. Later, versions of designs and relevant evaluation methods and results are also presented here.

In Chapter 5, we present the findings and results with reference to research questions and goals of our study. Also, limitations of the study are provided in this chapter. We further discuss the future possibilities for research and other opportunities that can help discovering new grounds in the areas we investigate during this thesis work.

In Chapter 6, a summary of the study is provided. We also present the main implications and reflect on the thesis work.

2. THEORETICAL BACKGROUND

Before diving into the world of social robots and their role and place in our environments, we should first provide the background for these terms and topics. Therefore, in this chapter, we look at social robots with a short reference to their history and meaning of their roles. This is followed by a closer look their place and role in public places. From society, human, and communication point of views, social robot's potential in human-human communication as part of the environment and their influence in social connected and engagement are also topics covered in the following sections. The theoretical background is concluded with a closer look at design aspects of socially interactive robots and robot-human interaction.

2.1 Social robots

First, in order to understand the context of social robots we first need to get familiar with what is meant by "robots" and "social" separately. Dictionary definition for robot goes as: a machine that can perform a complicated series of tasks automatically [2]. The term was first mentioned in a play written by the Czech playwright Karel Čapek in 1921 [3]. In the play, the term "robotnik" meaning "forced labor" (similar meanings in other Slavic languages) was used for referring to fictional humanoids (humanlike and non-human). These were mechanical men that are built to work in a factory and that strike against their human masters. Later, in 1940s, the term "robotic" was used in short stories for the first time by Isaac Asimov who also proposed the "Laws of Robotics". According to Asimov's laws, a robot may not injure human beings, nor allow them to get any harm. It is also stated that robots must obey orders and project its own existence as long as the actions does not conflict with the other laws [4, 5]. Asimov's laws and story brought more humanly qualities to robot's role in society which is more in line with how we would like to regard them in today's world, as well. In fact, with the help of Asimov's laws and fictional writings, the origins of robotic engineering were influenced [4, 5, 6].

Definitions of robots generally limit the functionality and their use to basic tasks. For instance, in 1979, Robot Institute of America defined robot as "a programmable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through various programmed motions for the performance of a variety of task" [3]. According to the International Federation of Robotics (IFR), robots should be divided into two groups based on the services they provide. First, those that are servicing humans

with tasks such as personal safeguarding, entertainment etc. Second, those that are servicing equipment in activities such as maintenance and cleaning [37].

The ability of interaction is what brings the social qualities to robots. Thanks to the attributes such as embodiment in the physical world, rapid reactions, and computational infrastructure to meet goals, and the ability to communicate with other robots to resolve difficult goals [10]. Duffy et al. [11] in their paper, discuss the theories of *social intelligence hypothesis.* One of these theories suggest that achieving a degree of intelligent behaviour from an agent requires embodiment both in physical and social environments. We look at “embodiment” more closely in the following sections.

The fact that there are two or more entities in the same context is what adds the “social” term to sociality of robots [3, 11]. Here sociality implies existence of interactive relationships between these entities. Thus, a robot with interactive skills and communicative behaviour can be considered social [11]. Although there are different approaches present in an attempt of understanding social robots, this provides the basics for the concept.

2.1.1 Social robots in public spaces

A public space is defined as a place that is generally open an accessibly to people. These include buildings that are open to public, and such spaces or environments [38]. In order to better understand how well social robots fit in our environments and find themselves a place that users can benefit from, we should look at the existing examples. There are a number of social robots that are already actively used in areas such us education, healthcare, research publicly. The interaction between users and these robots might not be same as the way they are in private use. Additionally, in public settings there could be observed difference in the way robots are perceived depending on the interaction type, design, and intended use. Therefore, a closer look in public space examples is beneficial for the rest of the study.

As a personal robot whose human interface and design make it useful individuals, Pepper was created by Softbank Robotics. An illustration of the robot is provided in Figure 2 with dimensions. Designed and developed as an emotional humanoid it is able to communicate with humans autonomously via speech, movements, and other recognition abilities such as facial recognition, object recognition, ability to sense gestures etc. Pepper was introduced with a cloud-based service which aims at providing the users with applications, content and other components for the robot. With these providing a great potential for improvements to existing solution and design, Pepper was used in a study with an attempt to develop an educational application for children. The concept of the

study was about children learning together with Pepper. The idea was to benefit from Pepper's unique capabilities in spaces such as home. Thus, school age children who learn English while having fun were chosen as the target group [12]. Similarly, an example from education domain could be the public library which uses the robot Pepper to teach kids and adults coding [39]. Another scenario where Pepper could be used in public; as announced by its creators, Pepper would have the ability to remind people to wear their masks in public settings during the pandemic (Covid-19) in 2020 and in future [40].

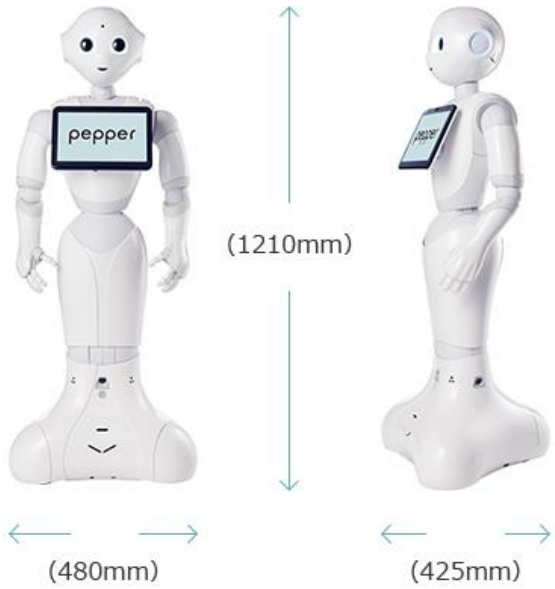

Figure 2. *Robot Pepper by Softbank Mobile [51]*

Nao is another humanoid type robot by Softbank Mobile Corp and previously owned by Aldebaran Robotics. Similar to Pepper, Nao was also used in a study where autistic children of moderately impaired intelligence were exposed to a simple interaction with the robot. The study aimed to test the hypothesis that NAO's human likeliness (blinking eyes, speech, playing music) and simple human-robot interaction (HRI) modules would be able to revive children's interest to engage in communication in the usual class setting. The results of this research showed that the children with moderately impaired intelligence show good response to robot-mediated interactions. [30]

Figure 3. *Robots Nao (I) and Paro (II) visuals [52, 53]*

Another example, Paro, the design purpose of the seal shaped robot was to provide therapeutic help. It is able to react to stimuli such as touch, sounds and light, and can adapt its behaviours to users according to their stimuli. In a study where the stress levels of elderly people living in a care house were measured, two Paro robots were placed in common areas. Residents could spend up to 9 hours a day around the robots and interact with them. Video recordings of the social space revealed that social tie among the users (residents of care house) were stronger than before. [13]

The visuals of robots Nao, as a humanoid, and Paro, as a white seal resemblance, are provided in Figure 3.

While it is a great challenge to operate the social robots in public spaces (in many ways including design, interaction, etc.) we still can find many examples of studies conducted with robots such as Pepper [32], NAO [30, 33], Robovie [34], and Paro [13]. [31]

During the time our thesis work was conducted, the pandemic in 2020 (Covid-19) has drastically affected our lives in many ways. As an example to public use of social robots, Pepper was placed in Athens International Airport in Greece to inform public on Covid-19 protection measures [66]. A representation of the scenario is shown in Figure 4.

Figure 4. *Pepper informing public on Covid-19 protection measures at the airport [68]*

Considering the coverage of studies already conducted in this area, as well as the developments and usage trends of social robots, there remains a need for deeper research on penetration of these agents in the public spaces and real world [30]. Therefore, in this study we discuss whether social robots can be considered as members of social environment as mediators of human-human communication.

2.1.2 Social robots as medium of communication

While we are still discussing whether people are ready for social robots in their own environment (public or private spaces) recent developments in robots are potentially changing the nature of service. One of the questions that still requires further research is whether the social robots can exist and act in our spaces as medium of communication. Thanks to their interactive and autonomous abilities, as well as the humanlike appearance, social robots are entering the realm of human social life. Their participance in human social life, emotional and verbal communication, and the emerging movement of social roboticization is leading to a change in how we define social interaction and the nature of human communication in society. [7]

Previous research has shown that icebreaking activities have the potential of creating positive environments and improve social collaboration and participation by reducing the tension between people [41, 42]. An icebreaking activity refers to a facilitation action that is meant to help members of a group get to know each other and form into teams, for example presented as a game [43]. Such activities encourage people to connect and increase communication between unfamiliar parties [41, 44]. In their study, Kaipainen et

al. [45] found that interaction with social robots in public spaces could lead to friendly encounters between people. In the same study, it is also proposed that socially interactive robots have the potential to facilitate connectedness between unfamiliar people [41, 45]. Similarly, we know from other study where Paro has been used in elderly care house the social tie among the users (residents of care house) were stronger after they started interacting with the robot [13]. Lastly, in another study where NAO was used to interact with autistic children, results showed that the robot could keep each child engaged during interactions; meaning that this had a positive impact to the children's communication behaviour [30].

There are a number of devices which people use on daily basis as medium of communication in order to communicate with those who are physically separated. Two-way radios, smart phones, computers, and others that support internet connection are only few examples. Socially interactive humanoid robots differ from such devices, as they are not a medium of communication through which humans interact, but rather a medium humans interact with [7]. Our focus in this study is mainly on the question whether social robots could be medium of communication while encouraging people to be socially more active and enhance their social participation. As discussed in earlier chapters, there are examples of research in this area, where the findings show positive effects on social interaction with increased communication.

2.2 Social engagement

In earlier sections, we discussed use of technology and more specifically socially interactive robots enhancing connectedness and collaboration between people. From a broader aspect, people's involvement and participation can be considered as "social engagement". the degree of an individual's participation in a community or society. In the next sub-chapters, we discuss social engagement and the way it is influenced by technology.

This section mainly focuses on the sustainable development concept by discussing the sustainability in social domain and exploring its development to our date. The discussion will help presenting the main foundations of social sustainability and how it will/can be improved in the future with the help of technology.

2.2.1 Social engagement and technology

According to the World Health Organization (WHO) social participation is classified as social determinant of health [26]. In the literature, social participation has been used interchangeably with social engagement. Social participation refers to interactions with

close contacts (informal) and community organizations (formal) via in-person visits. Social engagement, on the other hand, is about maintaining social connections and participating in social activities [27, 28]. Previous research on these topics show that technology can enhance social participation and mitigate social isolation. Although these studies mainly focused on how older people perceive social participation, results suggest that technology in general can influence social opportunities. [27, 28, 29]

Social sustainability as a concept in sustainable development context encompasses topics such as: social equity, livability, health equity, community development, social capital, social support, human rights, labour rights, placemaking, social responsibility, social justice, cultural competence, community resilience, and human adaptation [47]. These topics are indirectly or directly related to what we call social engagement as these can be maintained or sustained via continuous social participation and engagement. According to Bassuk et al. [28] define social engagement as the maintenance of various social connections and high-level participation in social activities.

Technology can provide benefits to people for social connectedness and engagement in many different ways. Especially, in terms of social engagement, the society can benefit from using the technology for community activity, event management, physical and mental exercises, virtual reality (VR), and social robots [48]. There are a number of studies conducted in topics investigating ways to enhance social engagement with various technology use. As in the mentioned example technologies, these consisted of research done with social robots, games, and apps. Some of these studies [27, 47, 48, 49] focus on social connectedness and engagement of middle aged or older adult groups. One of the main reasons for focusing on the older groups is the smaller network, reduced connectedness, higher social isolation [48] and lower quality of life. In general, younger generations are fast adopters of inventions and technologies, while elder user groups are relatively slow in adapting and using technologies (such as internet, smart devices etc.). This is exactly why technology can offer more benefits and opportunities to them by simply enabling them to stay connected despite reduced mobility and shrinking social network. On the other hand, regardless to their age group, all members of our society can be subject to these issues we discuss regarding social participation and engagement.

There are also studies conducted in similar topics that focuses on other user groups and technologies. For example, a study [50] focused on college students and other type of technologies such as smartphones and social media investigated how these could affect the social activities. The empirical evidence of this study suggested that there are positive effects of digital media use on social behaviours and in general increase the chance

of participance in social activities thus a positive impact on the student's social engagement. [50]

Under the light earlier studies shed on the topic "social engagement and technology", new ways and trends where technology becomes part of our social environment and enhance social activeness are discovered. Recent and future research with a focus on technologies role and potential in enabling society's members to be more communicated and engaged pose a great opportunity for achieving social sustainability globally. Although not covered under the scope of this thesis work, it should be noted that technology has a positive effect on other aspects of social sustainability such as livability and health equity. However, our focus remains on the use of social robots which are technologically advanced, smart, autonomous, and interactive devices that can have a great influence on connectedness of society and improve human-human connectedness.

2.2.2 Future of social engagement

Technologies role in our lives is becoming even more vital with developments in machine learning, AI (Artificial Intelligence), and robotics. Such developments are increasing the potential of social robots as their design and abilities are improved by those. Thanks to IoT (the Internet of Things) there are an increasing number of intelligent and autonomous technological solutions in our environments. As discussed in the previous section, such intelligent and autonomous devices, particularly social robots, are becoming a real part of our lives. We observe that social robots already support humans in many scenarios and activities. Furthermore, they have the potential to participate in human life by understanding or sharing feelings and emotions. [67]

In previous chapters, we mentioned social robots that are found to be helpful to older people who might be living alone or simply requiring support in different ways. We know that the current technology infrastructure enables such robots to perform complex physical actions. In addition, AI helps improving the robot-human communication which leads to a better interaction in general [67].

Since the invention of first robots, there has been an increasing number of industrial robots in factories and other spaces where they were found to be efficient and thus beneficial. With the technological developments, a shift in robotics from production (industrial) sector to houses, social services, and public sphere has occurred.

According to Fortunati et al. [55] there are two reasons why this shift in technological development occurred. First, society's new needs and desires in communication, information, emotional, affective, educational, and entertainment areas which can be handled

with social robots. Second, the domestic needs related to housework such as cleaning, ironing, cooking and others that can also be handled in more appropriate ways. Furthermore, it is suggested that the care sectors, health care, entertainment, education, and domestic spaces will be penetrated by robots in the near future. [7, 55]

During this shift we have also met internet and it has become an essential part of our lives. Internet and the new era it started poses a different importance in the social connectedness. Especially with increasing use of internet via social media and smart devices, we observe how technology can improve communication, social connectedness, and social engagement. Based on these, even virtual assistant (Amazon Alexa, Apple's Siri, Microsoft's Cortona, Google Assistant) that we interact through smart phones and devices can be considered as incubators of robot interfaces; suggesting that such devices are personalized and emotionalized social robots [55, 56, 57].

2.3 Design and UX in robot-human interaction

Design and acceptance of technology is two key factors in how the technology solutions become a part of human life. Without a doubt, human-technology and human-computer interaction requires a carefully planned research on the design before they are introduced and released to the world. Especially in our case, social robots where the main expected function is "interactivity" and the ability to communicate in a human-friendly manner, studying the design and embodiment of robots becomes vital. Therefore, embodiment as well as the user experience, acceptance of robots with regards to HRI design will be discussed in this chapter. There might be couple of subchapters based on the given phrases and key words.

2.3.1 User acceptance of robots

The word robot originally refers to "labour" according to some sources [4, 5]. Indeed, when they joined among us, they joined the work force by slowly replacing the factory personnel since they were found to be much more productive, efficient and durable. However, as Mori (1970) explains in his essay, these robots that replaces humans did not look like humans. In fact, although they imitate movements, industrial robots are far from looking like humans still in our day. Mori further discusses the sense of affinity by comparing industrial robots to toy robots in terms of human likeliness. This comparison is presented with the relationship which Mori describes as the "uncanny valley". Based on this, these robots replacing the human workers in factories must perform functions that are similar those performed by humans. Since these robots do not look like humans, and it does not matter whether do or not, in general, people do not feel affinity for them.

On the contrary, for toys, designers' focus is more on the robot's appearance than its functionality. Thanks to their human-looking form, children do feel attached to these toy robots [17, 18]. It is further suggested that there is a linear relationship between the human likeliness of robot's appearance and the higher affinity people develop for such design. An example could be a robot's arm made of metal with bolts, and the same arm covered skin and with flesh-like plumpness. Based on Mori's theory, the latter should naturally lead to a heightened sense of affinity. [17, 18]

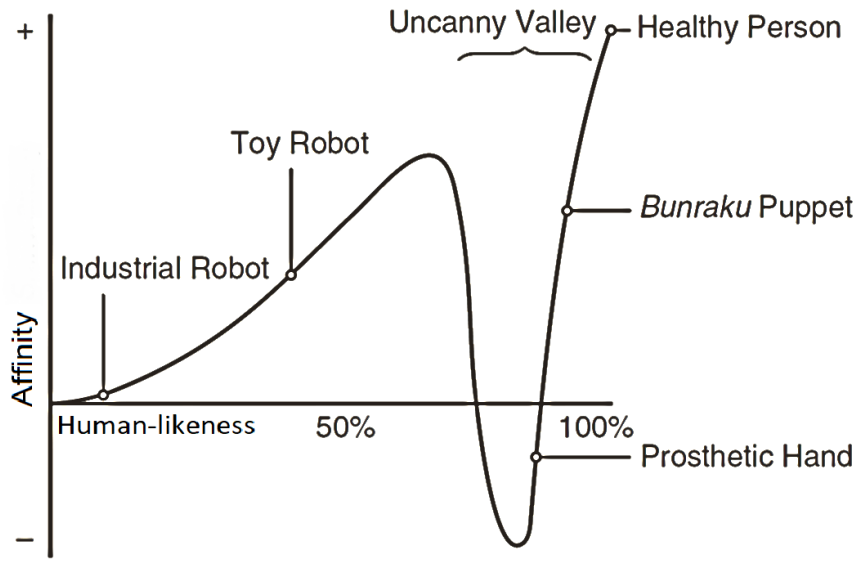

Figure 5. *The Uncanny Valley – The graph depicts the relation between human likeliness of an entity and the affinity related to it. Adapted from Mori's work [17, 18]*

As illustrated in Figure 5 above, the relationship between human likeliness and affinity do not always have a positive linear relationship. Mori's example [17] about the prosthetic hand falls in the area where the author describes as the uncanny valley. According to this, human likeliness of the prosthetic hand might trigger a positive feeling, however a person doing a handshake with the prosthetic hand could be startled by the limp boneless grip of its texture and coldness. As a result, our sense of affinity is lost. In this case, although the appearance of the hand is quite humanlike, the level of affinity is on the negative side, and thus the example is placed near the bottom of the valley. We understand from here that design of robots should not fall into the uncanny valley if we would like to have a positive affinity effect. In order to create a safe level of affinity, Mori recommends designers to deliberately aim at having a non-human design. [17, 18]

Considering the design of socially interactive robots, in line with Mori's study, it is critical for those to be able to engage in effective social interactions, since these robots are

interacting with users primarily through non-physical ways. Embodiment, as a fundamental concept studied in multiple disciplines, provides the opportunity to develop more channels for communication. According to Deng, Mutlu, and Mataric [20] embodiment is a necessity for robots that are in physical and non-physical interaction, although the benefits might be less obvious in virtual presence. Furthermore, in a study where the *embodiment hypothesis* [21] was tested, based on the results physically embodied interactions were found to be more favourable.

2.3.2 Embodiment and design

Embodiment is a term commonly used in different context including its different uses within the design context. We usually come across the terms embodiment design, embodied design, and embodiment in design. In our study, while some of these can be used interchangeably there are important nuances to be noted. As an example on industrial and one social robot visual is provided in Figure 6.

According to Dautenhahn humans need to be able to “place” themselves in agent’s body in order to effectively understand another agent; suggesting that a robot needs to have a body to be understood by people. Another view on this suggest that intelligence cannot be without a body, and a robot is “embodied” when it is physical, simulated and with a solid body. [24, 59, 60]

The satisfaction of end users, on the other hand, is an important goal in interaction and design. As many designers assume the satisfaction mainly depends on features of design, embodied agents are modelled with advance design features such as behaviour, speech, intelligent reasoning models, and realistic appearances. It is, however, argued that user satisfaction should be shaped by perceptions of the user and not only by design. Therefore, investigating embodiment in agent systems (social robots in this case) is crucial for understanding user’s satisfaction or dissatisfaction with embodied agents. [58]

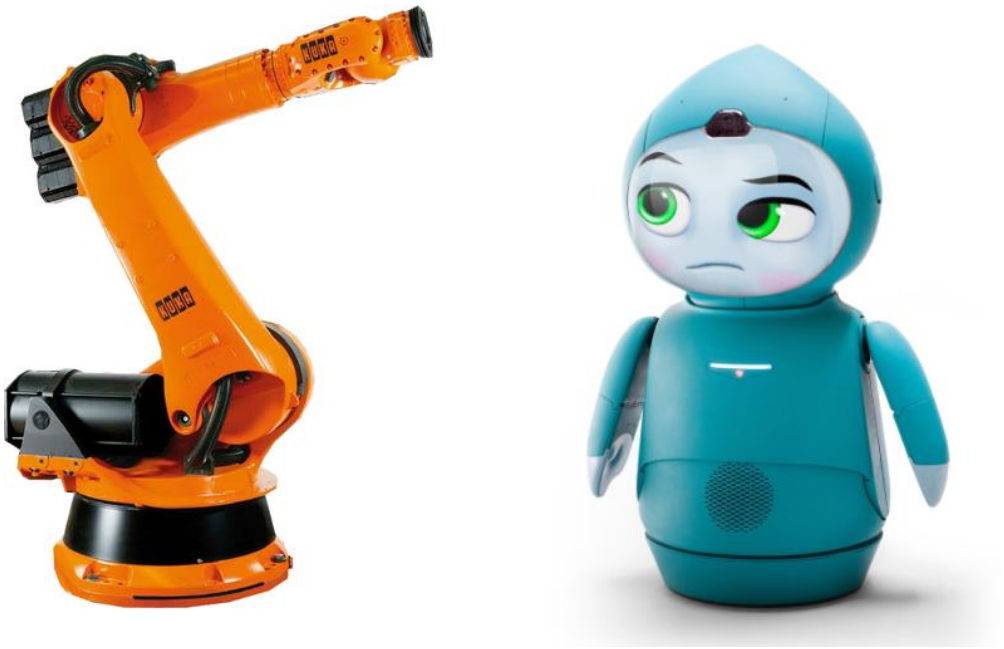

Figure 6. *An industrial robot (by KUKA) and an embodied social robot (Moxie).*

"The belief that something exists and resembles something 'real' is related to the design of the robot embodiment. What the robot represents may be of influence in whether users believe a robot is real, and therefore more engaging and likely to be used." [61]

In their study, Paauwe et al. [61] test the effects of social robot's form realism on engagement with a model called "interactively perceiving and experiencing fictional character" (I-PEFiC) which was originally developed by van Vugt et al. [58]. Using this model, they aim to investigate and explain how a user responds to interactive, fictional, humanoid characters on social robots. A figure detailing the I-PEFiC model is provided in Figure 7. The study [61] results provided that I-PEFiC model is an appropriate framework to apply in the field of social robots for predicting engagement and use intentions. However, most importantly, results suggested that a social robot embodiment which is designed to be more realistic is not perceived as more realistic, but it is their affordance and aesthetic appearance that makes them attractive. These results and deductions are in line with the study conducted by the developers of I-PEFiC model [58]. The study conducted by van Vugt et al. [58] in 2009 reveals that degree of realism (in the embodied agent) and perceived aesthetics contribute to user engagement. Also, helpfulness of the embodied agent in completing a task was found to be remarkably affecting user engagement. Furthermore, during this study, users were distant towards "ugly" looking characters, unless the ugliness was not compensated by helpfulness. Similarly, a trend was observed out that users seemed more willing to use a beautiful than an ugly agent, given that the agent was helpful.

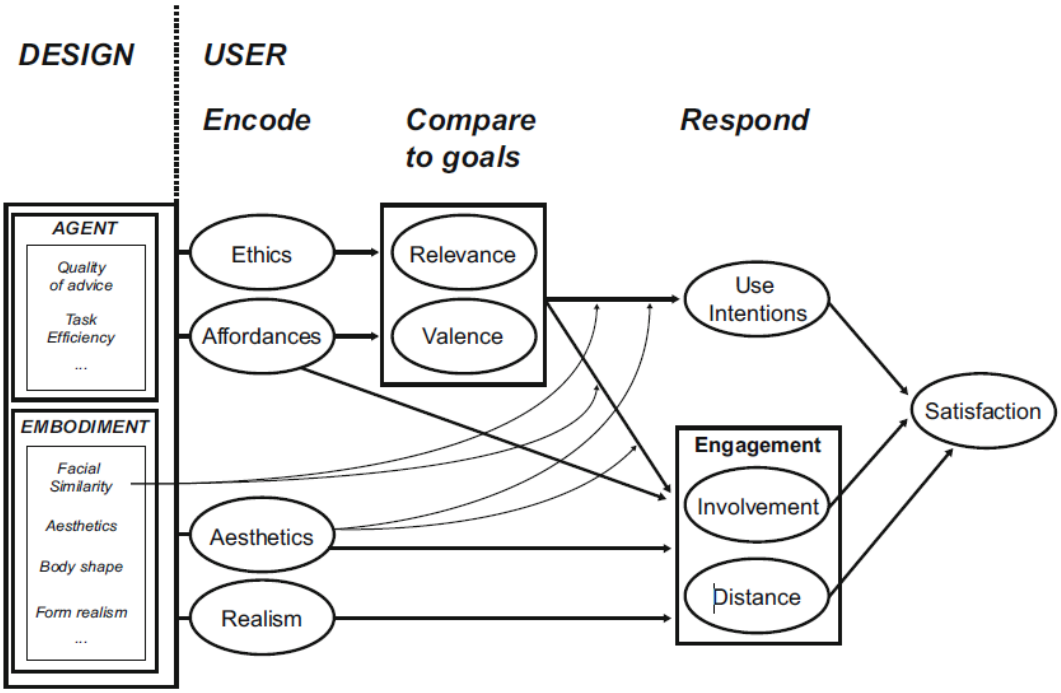

Figure 7. *I-PEFiC (Interactively perceiving and experiencing fictional characters. model). Adapted from the original version by Vugt et al. [58, 61]*

Considering the design of socially interactive robots, it is critical for those to be able to engage in effective social interactions, since these robots are interacting with users primarily through non-physical ways. Embodiment, as a fundamental concept studied in multiple disciplines, provides the opportunity to develop more channels for communication. According to Deng, Mutlu, and Mataric [20] embodiment is a necessity for robots that are in physical and non-physical interaction, although the benefits might be less obvious in virtual presence. Furthermore, in a study where the embodiment hypothesis [21] was tested, based on the results physically embodied interactions were found to be more favourable.

There is good amount research previously done on the topic focusing on design aspects of socially interactive robots (social robots as we refer in this study). These, however, deals with different design elements and attributes such as: facial cues, visual speech, virtual presence, face-to-face and virtual interaction etc. [19, 21, 22, 23, 24, 25] Although these could be considered as topics directly or indirectly related to user experience and user experience design, there remains a need for further re-search in order to determine what the actual user's prefer in design, communication, and interaction in general.

Deng et al. [20] investigates embodiment in socially interactive robots with the aim to discover more about specific design features and methods that could be used for more

engaging and effective robots. Since there are a great number of features in robot embodiment and the design space for such robots is vast, two focused and common dimensions are proposed: *design metaphor* and *level of abstraction*. Three example visuals showing a movement from abstract to realistic are presented in Figure 8. Design metaphor refers to design inspiration of a social robot (in our case). The metaphor is about robot's embodiment and its affordance for expected interaction partners and social interactions. For example, user's expectation for a humanoid robot with a mouth to speak is higher than for an animal-like robot. Indeed, there is a wide range of possibilities; cats, dogs, humans, and cars are some of the possibilities that the design metaphors cover for social robots. In their study, Deng et al. [20] classify and discuss abstraction in embodiment based on the primary design metaphor since it is possible to be inspired by more than one metaphor in design.

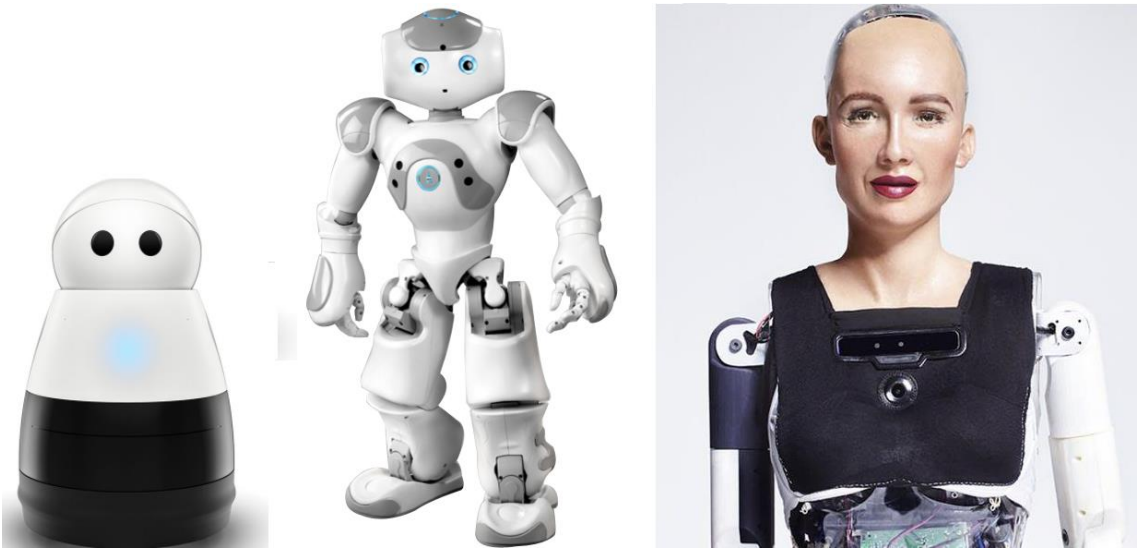

Figure 8. *Three example robot embodiments from abstract/metaphoric to realistic/literal. Robots left to right in order: Kuri [69], Nao [70], Sophia [71]*

We know that not all robots are designed to have a human-robot interaction. For example, industrial robots are designed to perform a task and interact with other similar robots or objects. Similarly, not all robot-human interactions are social ones since there can be non-social interaction between users and robots, as well. However, for a socially interactive robot with social engagement and communication abilities, design (e.g. appearance) still plays and important role. As we also discuss in the previous chapters, with an attempt to investigate social robots' role as a medium of communication Zhao [7] discusses the human-likeness of social robots by referring to importance of embodiment

and pointing out the attribute is the resemblance to human morphology in physical or digital forms.

2.4 Design implications and trends for social robots in public spaces

Regarding the design of social robots, we have gathered different approaches, models, and thoughts based on previous research. Although in essence these might focus on different topics, they reach a consensus on the importance of design, especially in the cases of social robots, social interaction, communication and engagement. In this section, we summarize and discuss the design implications that are commonly applicable. Additionally, design trends with some common usage scenarios that are observed in reviewed studies are presented where relevant.

Deng et al. [20] suggests designers of social robots need to consider both expected (cognition, processing, perception, manipulation, and HRI) and new challenges introduced by social interaction. Based on this, they present the following four design issues which are unique to social robots, originally introduced by Fong et al. (2013) [20]:

- Human-oriented perception: Social robots are required to have abilities for active and accurate interpretation of human activity and behaviour.
- Natural HRI: Social robots are required to display convincing behaviours, form appropriate expectations, manage social interactions with users, and follow social norms.
- Readable social cues: Social robots must have the ability to communicate their internal states with perceivable cues, and allow users to interact using their face, body, and voice.
- Real-time performance: Social robots must operate at a natural rate which is comparable to human interaction rates. They need to maintain a simultaneously competent behaviour, communication attention and intention, and conduct social interaction.

In terms of robot's role, functions, and the space where interactions might occur, we see a similar approach from multiple studies [3, 20, 62]. For example, Hegel et al. [3] social robots have social function, social form, and social context which all together forms the social interface. Social functions are those that can result in any artificial social behaviour, while social form refers to the elements that contribute to human-robot communication (such as robot having a face). Social context, on the other hand,

is the determinant of form and function. Altogether, social function, social form, and social context indicate categories that can serve as design guidelines that can be considered while designing social robots. In Figure 9, the relationship between these three aspects is depicted.

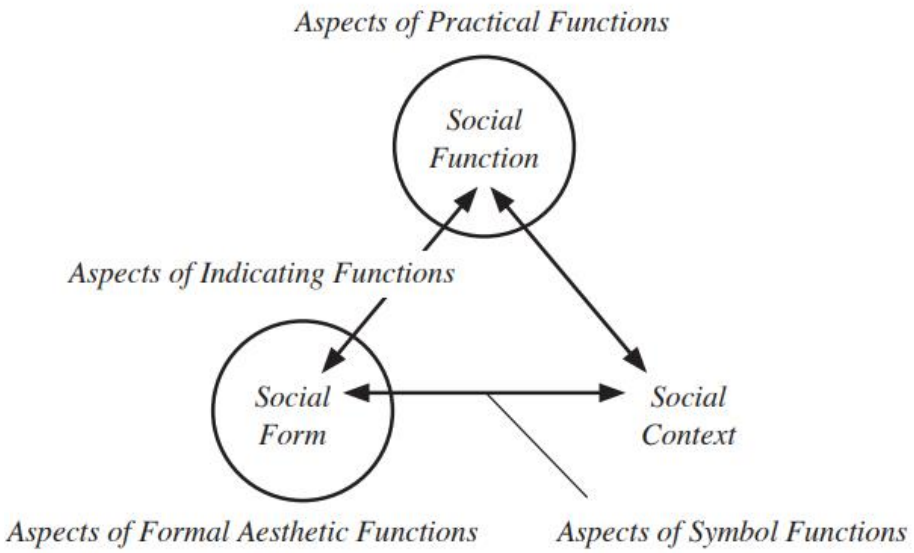

Figure 9. *Relations and aspects of social form, social function, and social context. Adapted from the original study [3].*

Deng et al. [20] proposes a model which is considered as a characterization of design process or selection of robots for different tasks. The process starts by identifying the robot's task and continues with the selection of a social role for the robot based on the task. Robot's role is related to its ability and approach for achieving its goals. Therefore, role should be carefully selected. In Figure 10, this process characterization is illustrated based on their work.

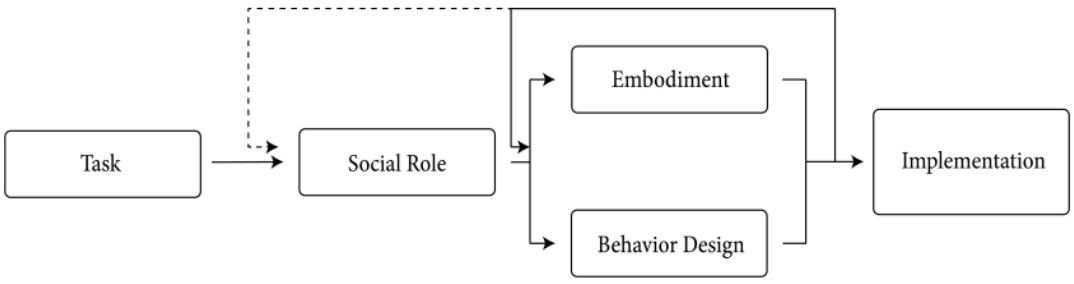

Figure 10. *Process of designing or selecting social robots for different tasks. Adapted from characterization of Deng et al. [20]*

In addition, it is worth mentioning that a gap between designers and researchers, who have different roles and approach in this process. This is due to the fact that social roles

are assigned to robots by designers as a design parameter, while the distribution of social roles across different task groups come from researchers' intuitions [20]. This gap may also exist for design in different fields as a potential conflict between designers, researchers (scholars), and users, since their views and angles might be bidirectional.

In addition to design (physical or non-physical) aspects of social robots, in a physical and social space where their interaction partners and other objects are present, robot's positioning acts as an important embodied cue in social interaction [20, 63]. These cues are referred to proxemic studied under human proxemics. According to this, the distance and orientation between an interaction agent and a human can have a strong influence on how people perceive robots (accepting and friendly versus disruptive and threating) [20]. Figure 11 illustrates the proxemic zones according to the distance groups that are relevant in social interaction.

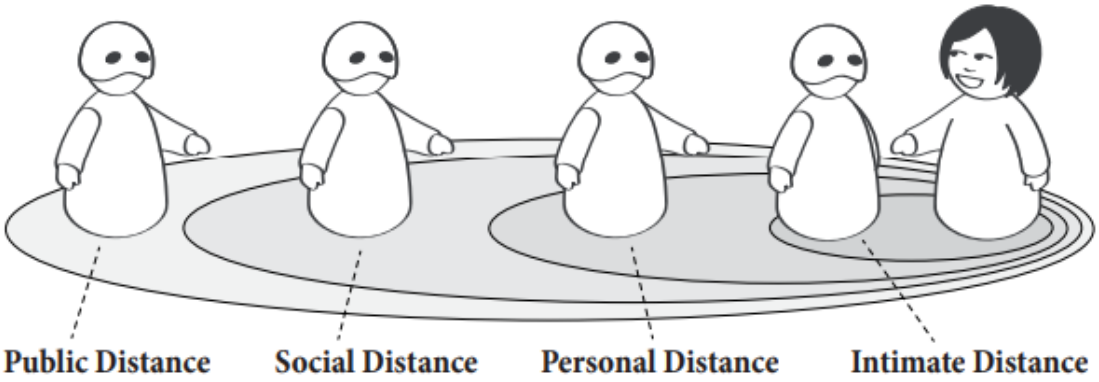

Figure 11. *Proxemic zones based on Hall's work [63]. Adapted from [20]*

van Vugt et al. [58] in their studies provide the following five design guidelines to be followed in designing embodied agents:

1. Realism is not that important for user involvement, distance, or use intentions
2. Beautiful is not always used
3. Affordances and ethics are essential in eliciting user involvement, distance and use intentions
4. Positive features do not always lead to positive effects, but negative features do
5. Relevance and valence of user goals are effect boosters

According to Šabanović [62], attributes such as speed, error rate, and strength are primarily technical ones which could be for industrial robots. However, these are not enough for social applications of robots to maintain a successful interaction. In general, the design of social robots requires a more open definition for robot design context. Social

robotics can be approached as a “wicked problem” for which designers must accept responsibility for. Therefore, there is a need for developing new design and evaluation methods for social robots. [62]

3. PRE-STUDY

For research in areas such as social robots and other advanced technologies which connect multiple disciplines including technology, psychology, social sciences, and design there remains still great grounds to be discovered. With an attempt to shed light on the user expectations, in this thesis work the process of design is initiated by a pre-study with which we aim to gain better understanding of which user experience goals should be focused on.

3.1 Observations

There is a great amount of observations which are relevant in thesis work since the author himself has been a part of the campus environment as an active member of the environment and has been engaging and interacting with different parties and spaces within the campus. We therefore believe that including the author's first-hand observations and experience would support the user study.

In general, there are certain methods for distribution of information to students and other campus residents (students, staff, academics etc.) at Tampere University, and specifically in Hervanta Campus. From student point of view, we observe that majority of information is available in text via printed material such as posters, leaflets, ads, notices, and other documents in designated areas or on bulletin boards. In addition, written information is also distributed through online university student portals (Sisu, intranet, POP etc.) as well as emails and distribution lists. There are also displays located in different parts of the screen that runs updated information on upcoming events, important dates, general reminders and others.

Scheduled social events are announced using at least one of these methods. Since the audience of events could sometimes be only specific groups (such as "IT staff only"), the channels used for distribution of information could be limited. Within the campus or university environment, there can be social events that take place once or as scheduled series. Despite the fact that information regarding these social happenings might be shared publicly, the chances for students missing them still remains high. While the main reason for this is that information is available only in text and in certain platforms, there is also the chance that interested parties will not notice it on time or will never be aware of such happenings. The same applies to student activities such as team sports, hobby and club activities, which are either student or university initiatives. Unfortunately, the

information related to such activities and social gatherings are not as widely available as they should be. Usually students or campus residents who are interested in such social happenings discover these via their network and contacts. Therefore, one can assume that word of mouth spreading is the most common and promising way in increasing the amount of involvement for such activities. However, this also points out one of the main challenges of social engagement.

Other than text sources, there are also visual-based information available. Sometimes, such sources do work as cues as they resemble the event itself and attract more. For example, a movie night event being advertised or announced with a famous movie poster or in shape of cinema tickets. Another example could be an event for volleyball games arranged in sports hall for which the potential participants can be invited with a picture of volleyball ball or just a photo from one of the games. Nonetheless, these are still not sufficient for reaching a general awareness or involvement in social activities. A picture showing written posts and information regarding the events in campus (Hervanta, Tampere) is provided in Figure 12.

Figure 12. *A stand with ads and posts in campus (Hervanta)*

In addition to limitations regarding the accessibility of information, the fact that some students who might not be part of larger groups, or who might not have a large network would have less chance for being informed or attending any activities. Especially, new students who are yet to discover the possibilities and opportunities within the university

would need to put extra effort on getting the required information. We observe that there is a growing trend of using social media in arranging meetings, events, gatherings and other social activities. However, the success of such social happenings and amount of participation in those is heavily related on the size of users it can reach. In other words, once again, students who are not part of any groups or larger networks can easily be left out from such events.

Other than these, there are also issues that can be observed frequently which are mostly related to interaction between students, academics, and staff. While language is one of the main barriers, amount of efforts students might need to put in certain scenarios is quite high. For example, students trying to get answers to their questions or simply trying to find a contact information might be challenging in certain cases. In addition, the fact that some information can only be available via specific sources and platforms makes the communication between different parties limited and challenging as well.

Based on these observations, it becomes clear that there is a need for a *connecting point* that can get more people informed, encouraged and engaged in what is happening at the university. It should be noted that gatherings, games, sports events, clubs, hobby activities, or other happenings have a great potential for connecting people from different backgrounds. For example, new students can meet their old student fellows, while in open events staff or academics can become acquainted and share with students. As a natural result, we could expect these to lead to more connected and social people which will spread the information and further increase the amount of activities and social involvement.

3.2 User study – interviews

3.2.1 Methods

A user study was conducted in the form of interviews as a part of pre-study in this thesis work. A set of questions were prepared and revised before the final version of interview. In total 8 questions were selected, 6 of which asks indirectly about the campus, socialness, and technology, while the remaining 2 directly points at social robots and their existence in the university campus environment. This naturally divides the question set into two parts. For the initial part, participants are not provided with background information, so that they can reflect own experience, thoughts, and feelings without bias. Meanwhile, the questions in the latter part of interview are asked to participants after a

brief introduction for social robots, since these require imagining social robots in the campus environment. Interview question template is added to this thesis as appendix. (See appendix A)

Interview notes were transcribed and grouped for a more detailed review. In order to analyse the gather data, we have used two different methods. Firstly, thematic content analysis was carried out on the data gathered during interviews as well as the observations. Secondly, the data was grouped in order to map the results from generic to more specific and to use these as input for design considerations.

Thematic and content analyses are the two methods used for analysing the data. These are considered under the descriptive design and are set of techniques used to study and explain themes. Main characteristic of these techniques is the way themes are created using a systematic process of coding [14]. A theme is used as attribute and an implicit topic that gathers repeating ideas in one group, enabling researchers to answer the questions of study. Themes are the main output of analysis that are products of practical results. Furthermore, themes are considered as results with underlying meaning which are deducted based on the information from subjective understandings of participants. [14, 15]

According to Erlingsson and Brysiewicz [16] transcribed interview texts are a common starting point for content analysis in qualitative research. Raw text including verbatim transcriptions of interviews to identify categories and structure themes is a process of abstraction of data from specific to generic and subjective to objective. In their study [16] Erlingsson and Brysieswicz describe themes as expressing data which are formed by categories, while the categories are formed by grouping the codes. A code consists of couple of words which describe the core meaning of shortened text data. Similarly, category names are also short, and they reflect what is visible and obvious in the data on a less abstract level than themes. The process is illustrated in Figure 13.

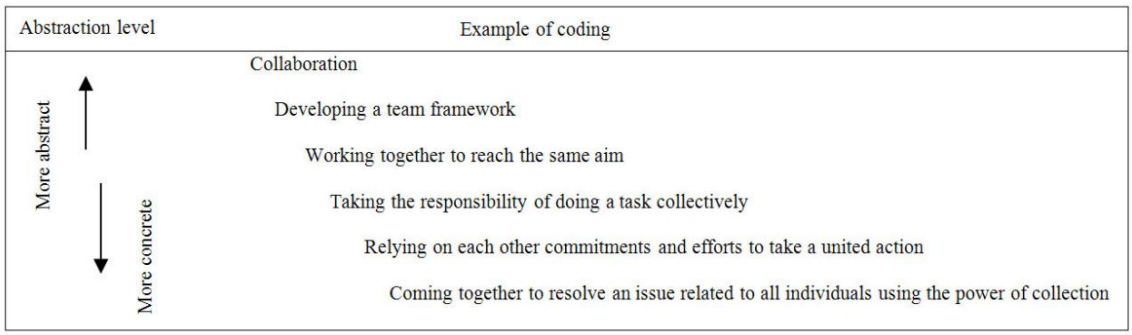

Figure 13. *Coding abstraction in qualitative content and thematic analysis [16]*

Earlier studies in thematic analysis show that an abstraction process should be followed step by step starting with codes, continue with categories, and conclude with themes. So that raw text data is first divided into condensed units, and then these are used to create labels (codes). Finally, grouped codes with a higher level of abstraction form the categories, and after iterative comparison, those are used for concluding even more abstract units, namely themes. [14, 15, 16]

In this study, while we follow the mainstream approach for the process of thematic analysis, a combination of applied methods was adapted in order to better match the research purpose. For example, instead of following a strict set of steps during the analyses to create categories, final themes were derived from observations and codes based on interview results. Our findings from the qualitative thematic analysis are presented in the following sections in detail.

3.2.2 Participants

Participants for the interviews were chosen among students of different campuses within Tampere area which are now united under one name, Tampere University. As these campuses are mostly international, interviewees also come from different backgrounds, cultures, and countries. In total 16 participants were interviewed with a fifty percent gender split (8 females and 8 males). Chosen participants agreed to arrange either a face-to-face session or an online meeting. At the time these interviews were being scheduled, global pandemic had arrived with the first large wave of cases, therefore some of the interviews were handled remotely.

The average age of interviewees falls between 20 and 26, and their nationalities are: Russian, Chinese, German, Turkish, British, Finnish, Israeli, Korean, and Sri Lankan. The fact that these participants come from diverse backgrounds provide a great opportunity in discovering different aspects of the scenarios and cases we are studying in this thesis. In the past some of these participants were students of the university and they continue to be a member of campus environment as researchers (academics). In a similar manner, this also provides a versatile group for the interviews which can result discovery beyond planned or targeted insights.

3.2.3 Findings

Findings are provided in the form of table below using the thematic coding analysis method. Responses collected from the participants are gathered and grouped in Table 1. By grouping the responses collected during the interviews, we identify first set of

codes. These codes are labels that summarize the collected data in few phrases. With an aim to further focus our findings and reach a conclusion point, themes are constructed with abstraction of multiple codes.

Table 1. *Summary of thematic analysis based on pre-study*

Theme	Code	Example
Ease of access	Accessing the interaction easily	*"No need to go through a process or set of steps to get response...*
	No time constraints	*"robots are available anywhere and anytime during the day..."*
Mobility	Availability on-demand	*Robots are not busy…* *They do not require appointment…*
	Location independency	*No need to look for specific locations or hours.* *More exposure to students*
Humanness	Approachable human-like design	*Robots are cute and attractive.* *…communication requires being face to face.*
	Face-to-face communication	*"Feedback and communication better given face-to-face"*
	Natural and personalized interaction creating sense of empathy	*Asking peers directly as they understand the needs and can relate…*
Simplicity	Language barriers	*"If you need to speak Finnish...language is difficult"*
	Independency from different tools and platforms	*"Diversity of tools and channels make problem solving difficult";* *"There are too many platforms "*
	Starting interaction easily	*Management is difficult to approach* *Staff is easy to approach* *Staff is friendly…*
	Promptness in communication	*Immediate response can be expected…* *Such solutions might be faster in problem solving…*
User-friendliness	Pleasant appearance	*Attractive and cute robots…* *Robots are not bored or annoyed with simple questions*
	Friendliness	*Natural and personalized communication* *Robots are cute and friendly"*
	Socially engaging	*People like robots.* *...people need a reason to communicate and engage...*

Based on these findings, we deduce from codes five main themes that will the main direction for our intended user experience goals that are required in design and conceptualization of a social robot for scenarios in university campus environment.

3.3 Design implications and considerations

In order to gather design implications to be considered in concept design, we need to summarize all our findings. Based on the results of interviews in pre-study and observations, we discover common areas in user interests and need that can be taken into account in design. In addition to the themes we present in the previous section, design considerations based on observations and other findings are provided below.

1. Ease of access
    a. Users can start interaction without formalities or barriers
    b. Time should not be a constraint for interaction (work hours, office hours, changing availability etc.)
2. Mobility
    a. Robots are available and mobile; they are able to move freely.
    b. Robots are visible and not tied to a certain place.
3. Humanness
    a. The design resembles human-like features while it is engaging and attracts attention
    b. Communication and interaction is direct and face-to-face
    c. Interaction is improved with empathy. Robots knows and understands the user.
4. Simplicity
    a. Language is not a barrier. Design supports user's language for easy communication.
    b. The interaction between robot and user is simple and straightforward.
    c. User gets immediate response and reaction from the robot.
5. User-friendliness
    a. Appearance of robot is pleasant.
    b. Robot is user's friend.

c. Robots are socially active and engaging. Design stimulates interaction.

While we aim at designing concepts based on the above, there are other important design considerations and ideas which are important to integrate in the design process. Firstly, as also mentioned in our observation notes, the role of social media in our lives cannot be neglected. There are new ways of social (as in social media) interactions and engagements discovered almost every day. Over time, some of these become even main methods of communication and even change the way we socialize. For example, Facebook, Hobbydeed, Whatsapp, Telegram etc. Therefore integration of features related to social media and internet should be a part of the concepts. Secondly, the number of robots in both public and domestic spaces are increasing. Especially during the Covid-19 pandemic that affected and changed our lives heavily starting from late 2019, robots were used in various roles and scenarios where human-human contact was required. In such cases, robots handled routine and manual tasks to avoid spreading infection. For example, airports, hospitals, shopping malls are some of the public spaces where the robots operated during the pandemic. Similarly, robots' role in the university campus setting becomes more important, and thus we suggest taken into consideration touchless and human-less interactions in design.

Figure 14. *Examples of the colours and their relationships for Tampere University brand [65]*

In addition to design considerations that we deduce from observations and pre-study, with reference to our university's brand, a specific colour set is considered in the design. Figure 14 illustrates the relationship of the selected colours based on Tampere University brand. We aim at having a sense of affinity and familiarity in the design by using this colour set.

Figure 15. *Tampere University Brand and main brand colour. Adapted from [65]*

Similarly, as the source inspiration for design, we have Tampere University brand with the slogan “Human Potential Unlimited” with a logo that resembles a human face and a humanoid. This gives us a good direction in having a concept design for social robots in campus environment which are socially interactive robots with humanoid and human-like features. Figure 15 shows the Tampere University brand.

In this subsection, we discussed the design implications and our considerations which are the basis for concept design and development. These provide use the guidelines and directions to be used in designing the concepts including social robots in the campus environment with a focus on above discussed design and user experience goals.

4. CONCEPTUALIZATION – DESIGN AND USER EVALUATION

In this chapter we present the design process based on our findings, design implications and considerations. As we discussed earlier in Chapter 1, this is the third step in our process, namely “conceptualization”. After briefly providing the details on design process and objectives, each concept is introduced under subchapters respectively. There will be in total three concepts we will be introducing. After the concepts are developed and introduced, we conduct a user evaluation study on the concepts. The objectives, procedure, and methods for the user evaluation are provided in the following subchapters. Finally, we discuss the results in the last section.

4.1 Design process and objectives

After the analyses based on the findings of pre-study, an ideation (I) step takes place, where different ideas on a concept with a social robot is developed based on design implications and considerations. In addition to design implications and considerations, for the ideation and following steps, Tampere University brand and relevant guidelines have also been included in the process. This is followed by the actual conceptualization step (II) where sketches were drawn for concept ideas and difference scenarios for concepted social robot were identified. Lastly, in the “user evaluation” step (III) we conduct a survey with users who are selected from the potential participants of concept scenarios. In addition to questions with ask to participant without introducing the concepts, we also ask follow-up questions after the introduction. These three stages of the process are illustrated in Figure 16.

Concepts presented in this chapter are developed as a combination of social robots and scenarios where their use can contribute to social engagement in the university campus (Tampere University, Tampere) environment and context. Therefore, sketches, visuals and other drawings, as well as the concept specific information including specifications and configurations provided in each concept should be considered as a whole.

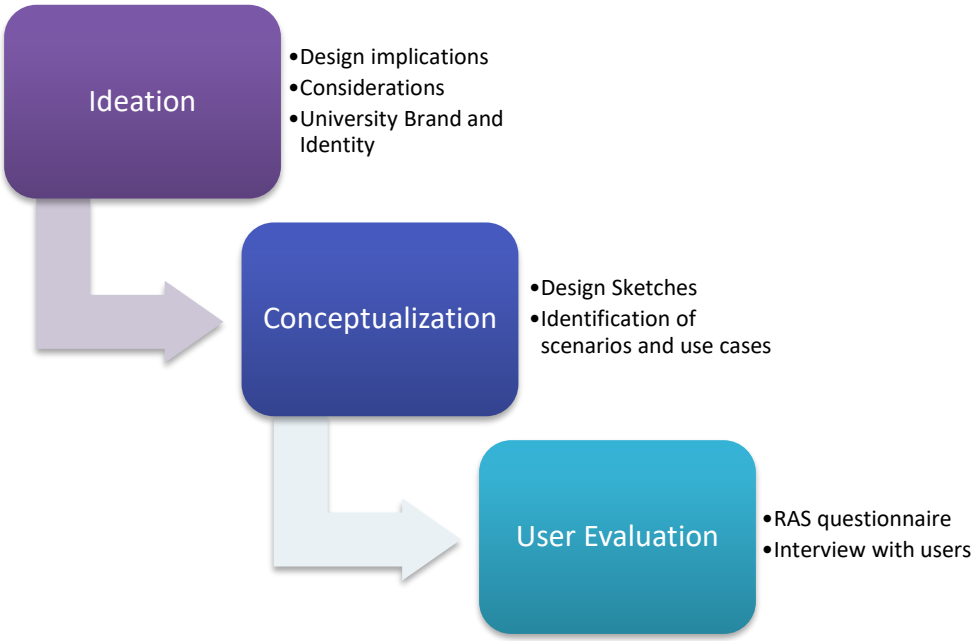

Figure 16. *Concept design process in three steps.*

As explained in the previous chapter, embodiment and other attributes in design that makes the interaction and agent itself more attractive are considered as in the focus of our concepts. For this reason, we aim at developing concepts with attractive designs that could enhance the social interaction. Since embodiment is an essential element of such designs, human-like attributes and abilities are part of the conceptualized social robot designs. In addition, design implications we reach from pre-study results are coupled with our considerations. Among these, the colour guidelines used for Tampere University brand are also included in the process.

4.2 Concept development

In the following subsections, we introduce three concepts including a social robot design in the campus environment. First concept is with the campus mate “Vodo” which is a friendly mascot-like social robot with highly social abilities. Second, we have a robot dog called “Dogo”, which is a friendly robot with interactive abilities. Lastly, we have a drone robot “Rono” with the ability to fly. The specifications, roles and scenarios with context are provided in detail for each concept in the following sections respectively.

4.2.1 Concept I – campus mate “Vodo”

The first concept is developed around various abilities of social robot called Vodo. It is a friendly and mascot-like social robot with human-like features. Vodo is intended to fill the gap in social interactions by providing all the missing elements in the communication, as well as bridging the communications. In order to better understand the concept, we

should look at specifications, physical characteristics, and the role(s) of the robot within the concept.

Figure 17. *Concept I – The campus mate social robot Vodo.*

Specs and physical characteristics

Vodo is made of a soft, foam like material that covers its hard plastic and metal structure (skeleton). The robot is 1.3-meter-tall and weights 35 kilograms. It has two hands, two legs, and two eyes. In addition, the robot has a mouth to support the speech abilities. Vodo's eyes are sensors that provides the infrared sense of its surroundings up to a distance of 10 meters. In the center of robot's face, there is a sensor and an HD camera in the shape of a "nose". These together also support the movement and other sight sensors used in face recognition. Thanks to its strong structure and soft joints, Vodo is able to move the head, hands, and arms in coordination which enables it to perform human-like physical actions and other tasks. Robot's visual is provided in Figure 17.

With its advanced social skills, Vodo is an active member of social media networks where the university and campus crowd is connected. This enables Vodo to be aware of all events, news, updates and share related information whenever needed. Additionally, students and others can share content or activity memos using these social media channels.

Having the ability of high mobility, Vodo can walk around the campus both indoors and outdoors. It can therefore accompany students on their way from one point in the campus to another one.

Role of the robot

Vodo is an experienced member of the campus who knows about the premises and recognizes the students and staff. Vodo's mission is to help the residents of university campus, and remove any barriers blocking socialness. It is a friendly campus mate for everyone who is a part of this environment. Acting as a tutor, Vodo helps students on their questions, doubts and in other cases where they require help. Most importantly, it attends to conversations and events as an active part of the society here.

Figure 18. *Students asking for Vodo's help in reaching and contacting others.*

In addition to its tutoring skills, Vodo connects students with each other and with staff (including academics). While responding to students when asked to help is a main activity for Vodo, it also actively encourages everyone for participation in social activities. These activities include: movie nights, hobby clubs, sports games, picnics, language practice groups and many other various examples.

Students who choose to share their activity record with Vodo via social media applications get personalized reactions from the robot. For example, Vodo can promote a social event to other students who share similar interests and connect more people in such happenings. Another use for the data would be that the robot reacts with cheerful and fun feedback to students who share their social activity and who connect with others By doing so, the robot eventually aims to encourage everyone in more actively attending

the events and connecting with other students. An example information and interaction flow regarding this feature is illustrated in Figure 19.

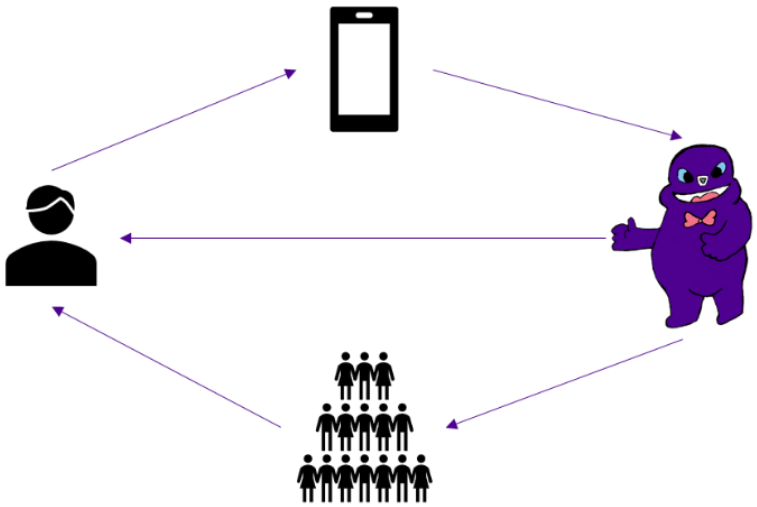

Figure 19. *Students sharing via internet and being connected by Vodo.*

Another example scenario is illustrated in the Figure 20. Vodo talks to a student who is interested in participating in social events; in this case a football tournament where students for teams and play against each other. The person in our example is an international student who finds it difficult to understand or follow the rules and requirements of the tournament since information is available in Finnish only (poster on the wall). The student also needs a team thus there is a need to connect him with other students who are interested in participating in this event. Therefore, Vodo reaches out to organizer and other students and have everyone connected for this social event.

Figure 20. *Vodo helping a student connect with others in a social event.*

Vodo's purple colour and appearance together resembles Tampere University's brand which gives the users a sense of familiarity and friendliness. The colour Pantone Medium Purple C (CMYK: C91 M97, RGB: R78 G0 B142, HEX: # 4e008e) [65] was specifically chosen for this embodied agent to have a character based on human-like appearances and characteristic that reflects the relation to the university itself.

4.2.2 Concept II – campus guide "Dogo"

Our second concept is based on a dog-looking social robot that acts as a campus guide which is called "Dogo". This robot is intended to welcome students and attract them for interaction with an aim to get them closer and eventually connect. As an attractive, friendly looking campus pet, Dogo is a social robot with a highly social ability. In order to understand the concept better and get a sense of Dogo's potential, we should first go through physical characteristics and robot's role in the concept.

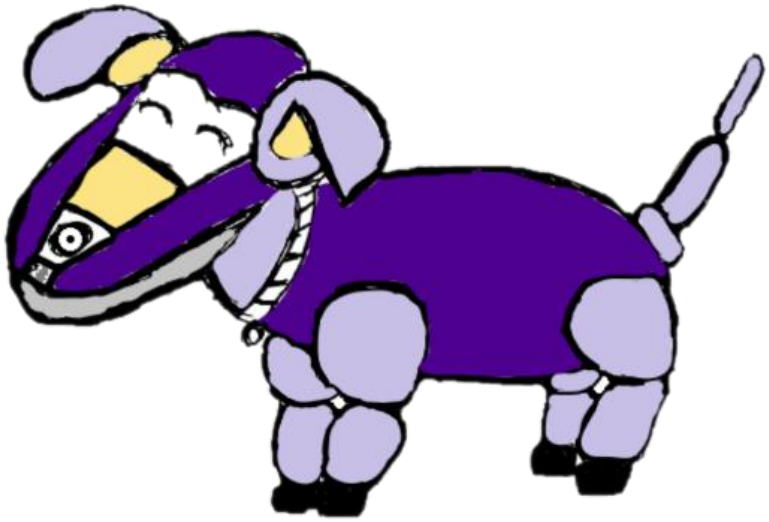

Figure 21. *Concept II – Campus guide dog "Dogo"*

Specs and physical characteristics

Dogo is made of a medium-soft plastic and metal material that covers its metal structure (skeleton). The robot is 4-centimetres-tall and weights 12 kilograms. It has fourlegs, and two eyes. In addition, the robot has a mouth to resemble a real dog and support audio feedback. Unlike Vodo, the robot dog does not support speech. However, it is able to hear and react to voice and speech with certain sounds. In addition, with speakers embedded to its body, it can also play certain sounds. Dodo's eyes are sensors that provides the infrared sense of its surroundings up to a distance of 15 meters. In the center

of robot's face, there is a sensor and an HD camera in the shape of a "nose". These together also support the movement and other sight sensors used in face recognition of students and others. Thanks to its strong structure and joints, Dogo is able to move the head, legs, in coordination which enables it to perform reactions and tricks. Unlike Vodo, the robot dog Dogo resembles a dog and therefore performs pet-like actions. In addition, the robot has a tail that can move both horizontally and vertically during the interactions to provide an even more realistic reaction and behaviour. Robot dog Dogo's visual is provided in Figure 21.

Role of the robot

With its advanced mobility skills, Dogo is an active member of the campus moving rapidly from one place in the campus to another. Stimulating the need for interaction, Dogo connects with students and others that where the university and campus crowd is connected. Thanks to its sensors and camera, Dogo keeps a track of happenings around the campus and streams them live in the screens located in different spots at the campus. This enables students and campus residents to be aware of all events, news, updates and access to related information whenever needed. Additionally, students and others can have photos taken by Dogo by requesting and interacting with it.

Having the ability of high mobility, Dogo can walk and run around the campus both indoors and outdoors. It can therefore accompany students on their way from one point in the campus to another one. Using its high mobility and familiarity with the campus, the robot can guide new and old students from a point in campus to another one as well as to a location or office where a specific person is located. For example, you can request Dogo to show you the way to a classroom or a specific office, and it guides you until there, and leaves with a "happy" face and single barking.

Figure 22. *Students asking Dogo to show the way.*

In Figure 22, an interaction scenario between students in the campus and the social robot is illustrated. This is made possible by Dogo's skills in finding the way within the campus and navigating using it's skills and features enabled by GPS (Global Positioning System) technology and system. Dogo is also able to mark and remember location of people within the campus, such as offices, desks and booths. Additionally, the robot stays connected to all surveillance and campus information system, which makes Dogo aware of the happenings and people flow. In Figure 23, we see another illustration for the scenario where Dogo interactions with new students during the orientation program that takes place on students' first few days at the university.

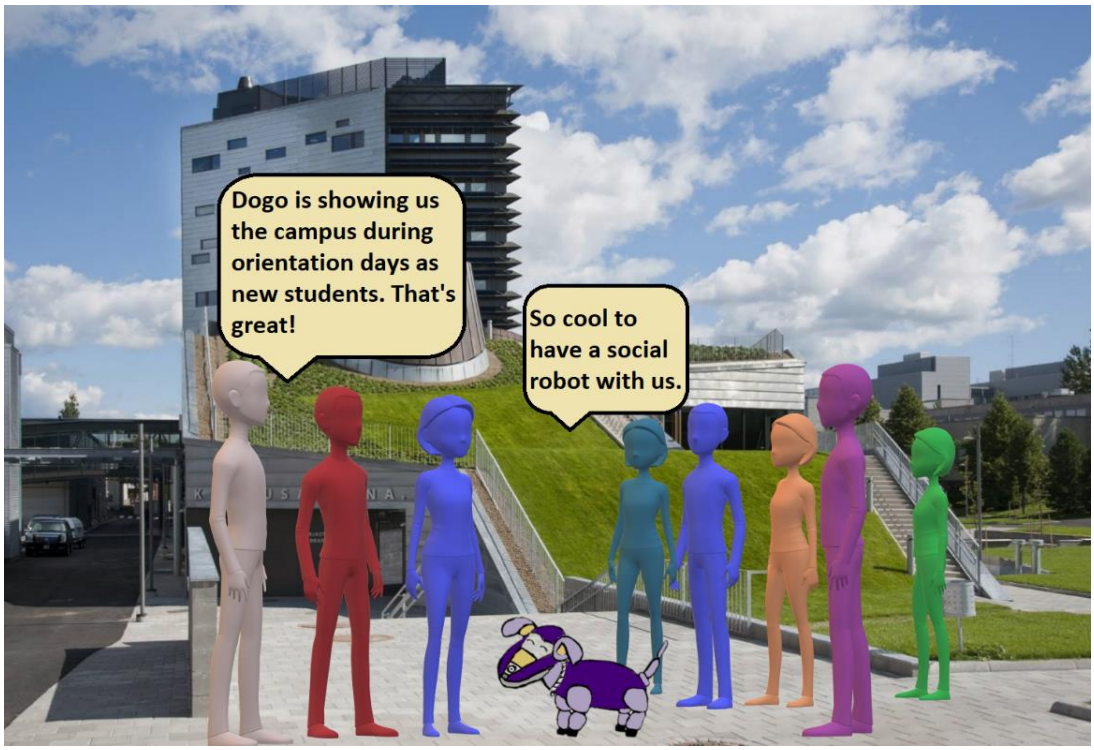

Figure 23. *Dogo interaction with new students during orientation days.*

In order to start an interaction with Dogo, users need to be within an active perimeter which could be considered in the proxemic zone [20, 63] for social interaction. This triggers Dogo's attention and an interaction is automatically initiated. Using the active zone rule, Dogo is not distracted with the movements or events taking place far from it. The distance can be determined in Dogo's programmable system and "interaction sensitivity" can be adjusted.

Dogo also takes after the purple colour from the Tampere University brand. The design includes colours that are available in brand colour relationships [65] gives the users a sense of familiarity and friendliness. The colour Pantone Medium Purple C with yellow and light purple [65] were specifically chosen for this embodied agent to have a character based on a realistic embodied appearance and characteristic that reflects the relation to the university itself.

4.2.3 Concept III – flying guide "Drobo"

The third concept includes a robot with relatively different features to the first two robots introduced in previous sections. This social robot called "Drobo" is a flying drone with various interaction abilities. Drobo is developed as a flying robot which allows high mobility. It is a friendly social robot with human-like features. Drobo is intended to accompany students and campus residents during their days and social activities. While accompanying the users, the robot keeps record of the activities and events taking place

in the campus. In order to better understand the concept of this flying social robot, we should look at specifications, physical characteristics, and the role(s) of the robot within the concept.

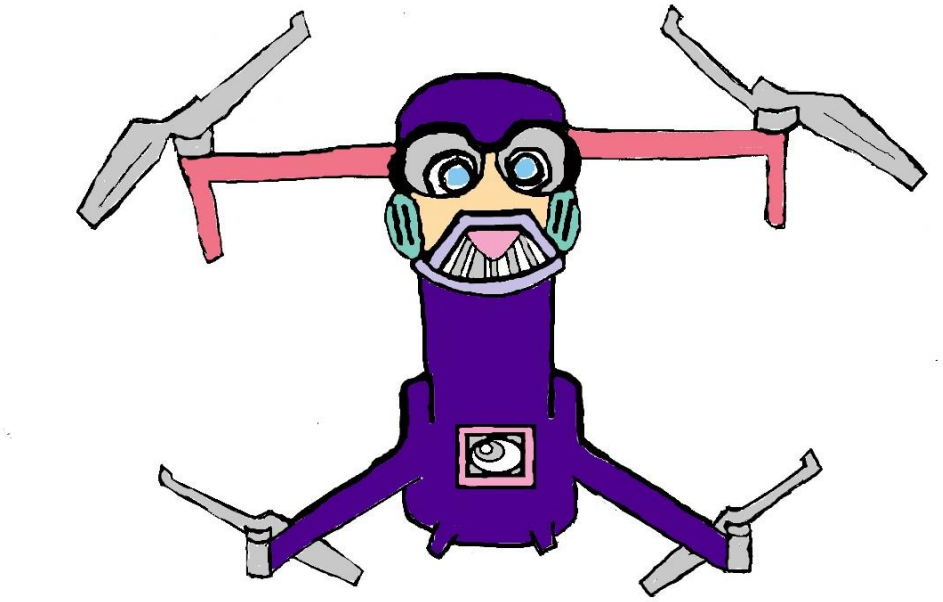

Figure 24. *Concept III – Flying drone robot Drobo.*

Specs and physical characteristics

Drobo is made of carbon fiber-reinforced composites, thermoplastics, and aluminium material that covers its hard plastic body and metal skeleton in the core. The robot is 0.35-meter-tall and weights 1.7 kilogram. It has two arms, two legs, and two eyes. In addition, the robot has a mouth to support the speech abilities. Each limb of Drobo has a propeller that enables flight. The eyes of the robot are sensors that provides the infra-red sense of its surroundings up to a distance of 8 meters. Drobo's eyes are also HD cameras. The big lens on each eye make it possible to take photos, record and stream high quality videos. In the center of robot's eyes, there is another sensor that supports the movement and face recognition. Thanks to its strong structure and joints, Drobo is able to move the head around its axis. Both arms and legs are connected to the main body with joints that move in coordination which enables it to perform human-like physical actions and other tasks such as standing, sitting etc. Drobo's illustration is provided in Figure 24.

Role of the robot

Drobo is familiar with the campus who knows about the premises and recognizes the students and staff. Drobo's mission is to monitor the happenings and share them with everyone. It is a friendly social robot in the campus for everyone who would like to share

and interact. Acting as a guide, Vodo helps students with their questions, and can show them around in the campus. Most importantly, it attends to events as an active element in social environment here. A potential interaction encounter is illustrated in Figure 25.

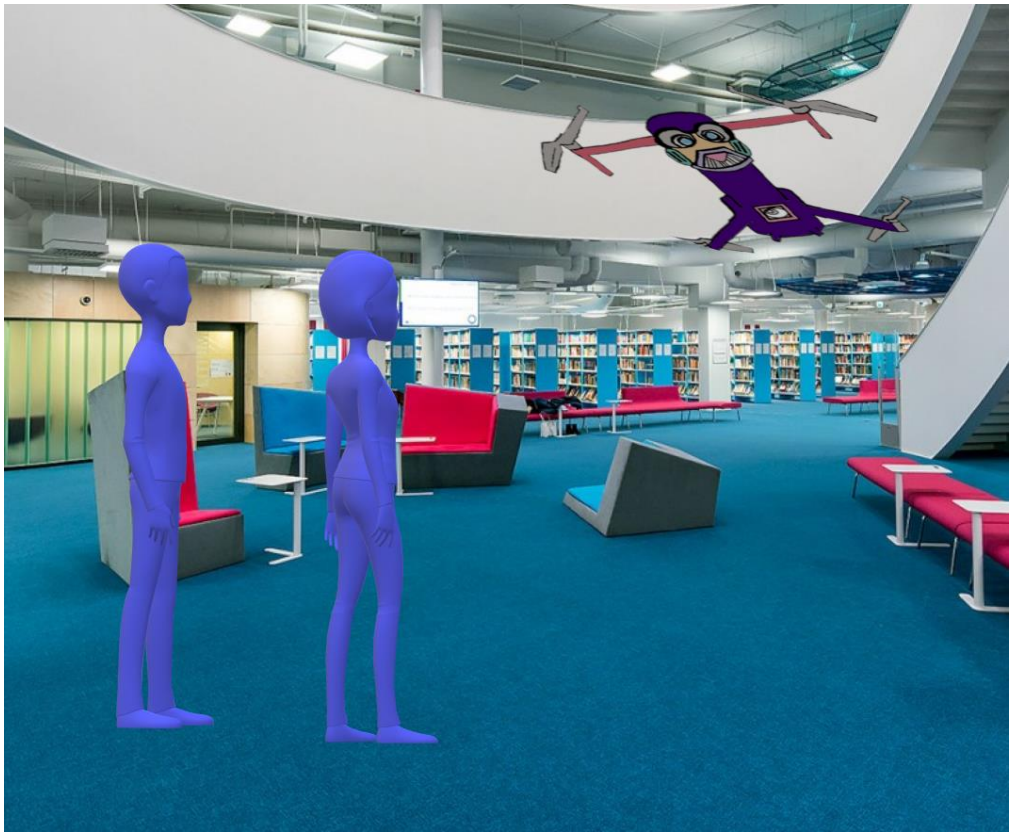

Figure 25. *Drogo interacting with students while hovering in the air.*

With its advanced mobility skills, Drobo actively flies and moves around the campus as an active member of the campus. This enables Drobo to be aware of all events, news, updates and share related information whenever needed. Using its eyes and mounted cameras, it can record and stream activities from students and campus crowds. For example, the screens around the campus at different locations can show what is happening around the campus “from eyes of Drobo”. This can be repeated on a regular basis with a time limit (e.g. screens show what Drobo sees every fifth minute) Additionally, students and others can share content or activity memos using these social media channels by tagging Drobo in their posts. The robot can then filter these contents and share it with other students to get their attention, to advertise different happenings, to invite, or to simply encourage them towards interaction.

Students, groups, and clubs who choose to share their activities and events can interact with Drobo and record or stream what is happening in their events with other students around the campus. Drobo can create posts in social media and stream videos of these events to reach larger networks and crowds. Especially when a special event takes

place, Drobo can notify students and other campus residents who might potentially be interested based on their profiles. Figure 26 shows how the information regarding these social events and interactions is shared.

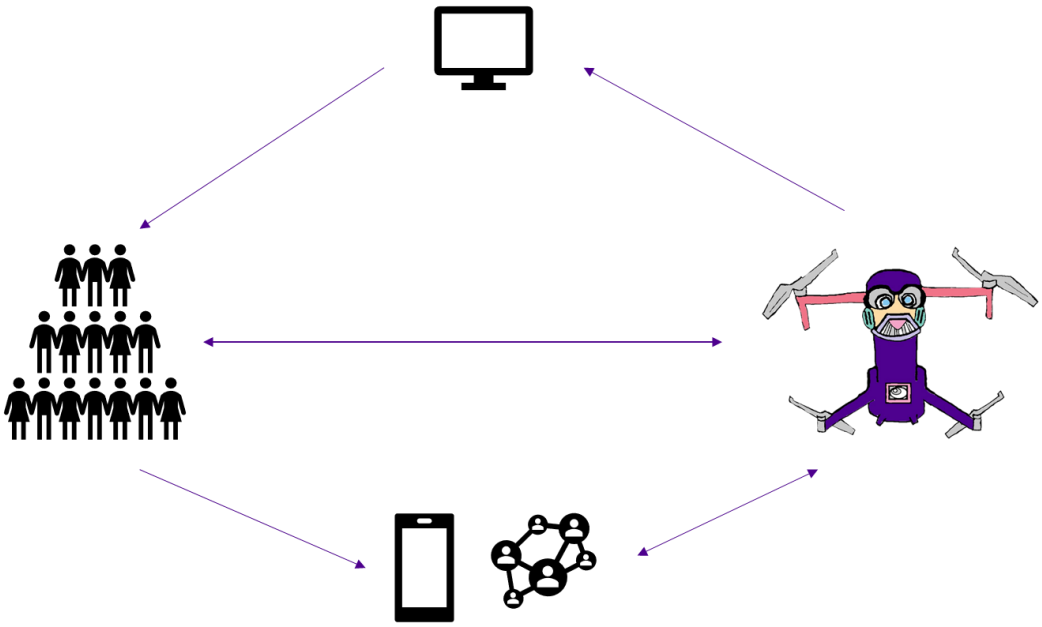

Figure 26. *Students sharing via internet and being connected by Drogo.*

Lastly, Drogo's purple colour in the body and appearance together resembles Tampere University's brand which gives the users a sense of familiarity. The head of the robot also has human-like features and attributes. The colours Pantone Medium Purple, yellow, green, blue, red, and pink [65] were chosen for this embodied agent to have a character based on human-like appearances and characteristic that reflects the relation to the university itself.

4.3 User evaluation of concepts

In this section, we explain the user evaluation conducted for the three concepts introduced in this study with details. In Chapter 3, we discuss the pre-study process and our findings based on the user study. Findings of the pre-study helped us draw design implications for the introduced concepts. In this chapter, we discuss the process of user evaluation of the concepts including objectives, procedure, and methods. Finally, we present the results at the end of the section.

4.3.1 Evaluation methods

For the user evaluation, we use questionnaires for which the answers were collected via online forms and online meetings in a semi-structured interview format. In order to assess participants views towards the social robots, we use the Robot Attitudes Scale (RAS) [36]. RAS is a 12-item measure where participants rate the social robot on 12 attributes with an eight-point scale. According to this an attribute is rated with a score between 1 and 8; with 8 being the highest and equating to more favourable robot attitudes.

Using the visuals of concept designs, participants were asked open-ended questions to gather an in-depth understanding of their perception after the RAS questionnaire. Later, collected answers were compared with RAS questionnaire scores to identify any relationship or correlation between the pre- and post-introduction attitudes.

Both RAS questionnaire and open-ended questions asked during the user evaluation interviews are provided as appendix at the end of the thesis. (Appendix B and C)

4.3.2 Objectives, procedure and participants

As discussed at the beginning of Chapter 4, after the ideation step in the design process (Figure 16), concepts were developed with sketches and identified use case scenarios. Later in the process, in order to better understand how people perceive the concepts, using a questionnaire (RAS) and open-ended questions, the concepts were evaluated by users. In line with the research questions and objectives of this thesis study, a set of questions were determined to be asked to participants during the user evaluation process. The questions were aimed to help gathering users' insights and understanding on the concepts which could eventually contribute to better assessment of design.

RAS questionnaire (Appendix B) was provided to participants via an online form prior to introduction of concepts in detail. Participants were only provided with visuals of social robots in the three different concepts and asked to fill in the questionnaire based on their initial impressions and views. After this step a semi-structured interview was conducted, where each concept were introduced to participants with visuals and example scenarios. Later, participants were asked to answer a set of open-ended questions (Appendix C).

Similar to pre-study, participants for the user evaluation were chosen from students of different campuses within Tampere area. As these campuses are mostly international, interviewees also come from different backgrounds, cultures, and countries. In total 10 participants were interviewed with a fifty percent gender split (5 females and 5 males). Chosen participants agreed to arrange an online meeting for the user evaluation. At the

time these interviews were being scheduled, global pandemic had spread globally with large wave of cases, therefore the interviews were handled remotely. The average age of participants falls between 19 and 33, and their nationalities are: Russian, Korean, Latvian, German, Turkish, British, Finnish, Israeli, and Sri Lankan. The fact that these participants come from diverse backgrounds provide an opportunity in discovering different aspects of the designed concepts.

4.3.3 Results

After all 10 participants provided their answers for the RAS questionnaire based on their initial views and attitudes for the concepts, collected quantitative data has been analysed with a basic statistical analysis. In addition, a content analysis was conducted on the qualitative data collected through semi-structured interview as the final step after the RAS questionnaire. Below we present the results from both qualitative and quantitative data.

According to the accumulated results for each of the 12 category used in RAS questionnaire, lower score indicates less favourable attitudes towards the social robot, while higher score indicates favourable attitudes. Based on this, analyses show that Concept II (social robot Dogo had the highest overall score with a total of 611 points out of 960 (10 participants X 12 attributes X 8 points). This was followed by Concept I (Vodo) with 594 points and lastly Concept III (Drobo) with 539 points.

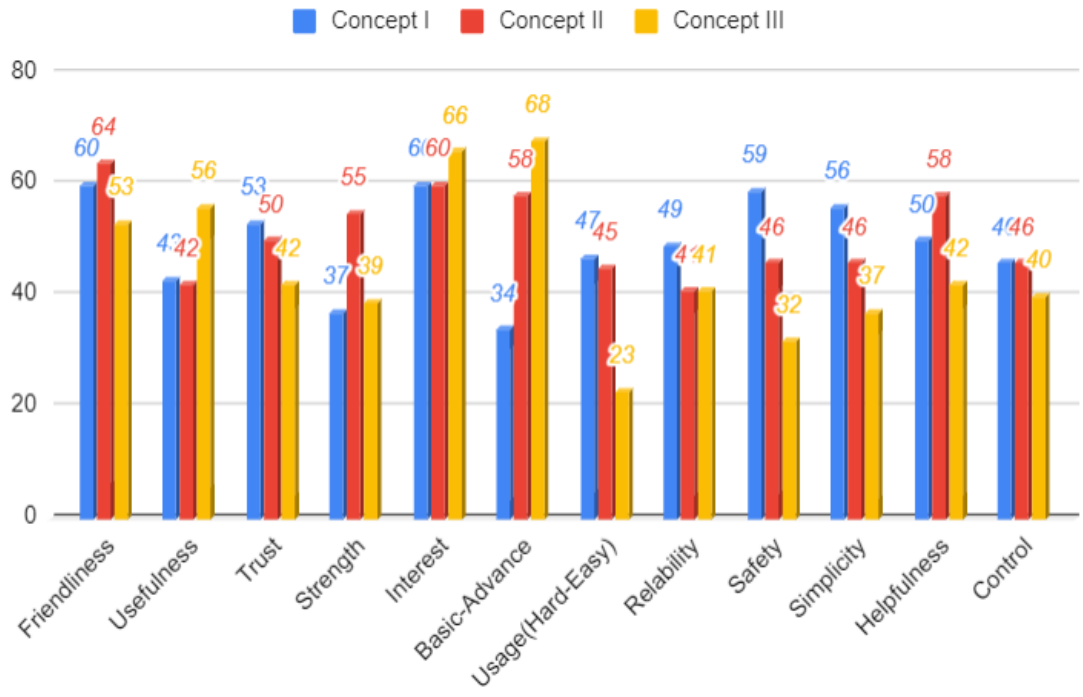

Figure 27. *RAS questionnaire results per attribute and concept.*

The results for each attribute and concept is illustrated in Figure 27 based on the RAS questionnaire results. In order to simplify the chart, attribute names were revised. The score for each attribute is provided as data label on each bar. These indicate the total number of points a concept scored for a given attribute based on responses from 10 participants. For example, results show that although the concepts were found to be generally interesting (all with scores 60+) and friendly (53-64), some other attributes such as “Trust” and “Reliability” and “Usefulness” remained low.

Table 2. *Detailed attribute score comparison per concept*

	Friendliness	Usefulness	Trust	Strength	Interest	Basic-Advance	Usage(Hard-Easy)	Reliability	Safety	Simplicity	Helpfulness	Control	
Concept I	60	43	53	37	60	34	47	49	59	56	50	46	*594*
Concept II	64	42	50	55	60	58	45	41	46	46	58	46	*611*
Concept III	53	56	42	39	66	68	23	41	32	37	42	40	*539*
	177	*141*	*145*	*131*	*186*	*160*	*115*	*131*	*137*	*139*	*150*	*132*	**Total**

In Table 2, a detailed comparison of attribute scores for each concept is provided. The purpose of grouping and using such colour format in the table is to provide a better understanding of each attribute and how participants’ attitude scores are distributed over concepts. According to this, we see that “Interest” attribute scores the highest within each concept and also overall compared to others, while “Strength” and “Reliability” share the last place with the lowest score 131. In other words, designs were in general found to be interesting for all concepts, while strength, reliability and control had the lowest performance.

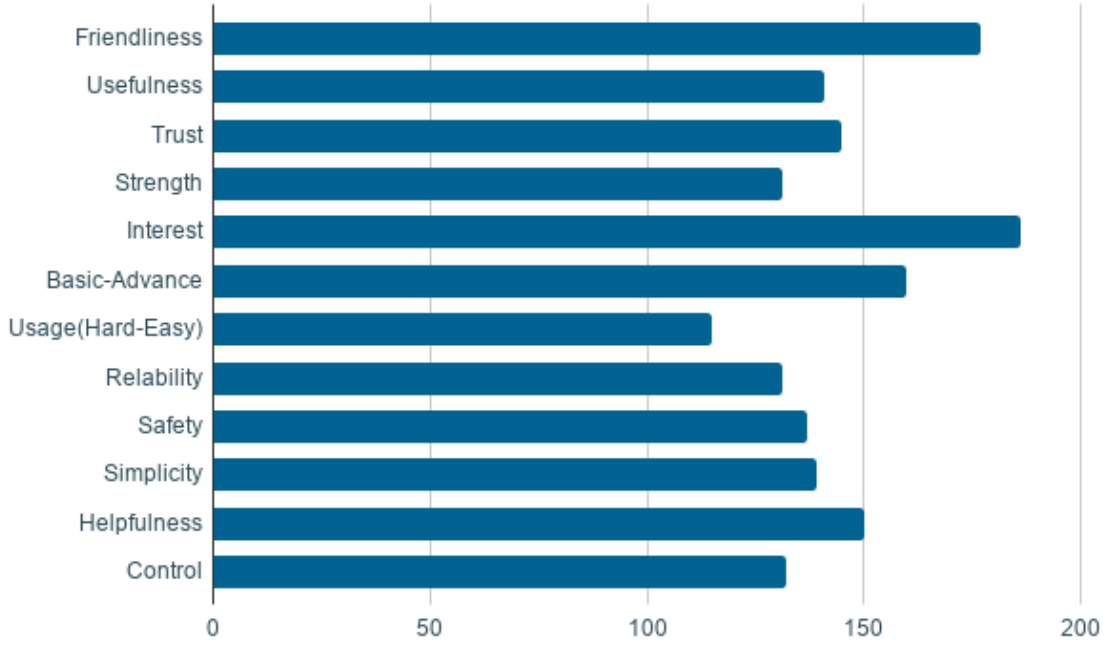

Figure 28. *Overall score comparison per attribute*

As we can see in Figure 28, as a total of scores given by participants to all three concepts, following attributes were found to have highest positive attitude from participants: friendliness, interest, basic-advance, and helpfulness.

In addition to the above discussed quantitative results, content analysis conducted using the qualitative data through the open-ended question revealed a set of focus areas. These are discussed further below.

Perceived ease of use and communication

More than half of participants indicated in their responses that the interaction with the social robots in all three concepts should be easy to start. Participants stated that they are interested in interacting with the robots and being a part of the environment robots are in. In general, most participants found the robots attractive and stated that they feel the communication would be easy. For example, one of the participants suggested that they would approach Vodo (Concept I) as they approach one of their friends. In line with this statement another participant stated “it will be a natural dialog with the robots” suggesting that there is no procedure or specific actions to be followed. Similarly, two of the participants mentioned in their responses that students can comfortably and confidently approach social robots knowing that there is no need for certain phrases or gestures to start the interaction.

As it has been mentioned to participants during the introduction of concepts, participants referred to the social robot as highly intelligent agents therefore in their responses assumed that the communication and dialogues between users and social robots would be smooth. More specifically, some participants stated that the robot would handle complex communication and it can respond to different questions and requests without too much hassle.

Recognizing robot's social ability and influence

Majority of the participants stated in their responses that they found the social robots attractive, friendly, engaging and easy to interaction with. Coupled with this perception, participants mentioned how these robot's could be part of the social environment in the campus. For example, one of the participants answered that through these attractive interactions with social robots, students could gain confidence in social interactions. Especially regarding new students who are fresh in the social network withing the campus environment and unfamiliar with the university, having social robot's available for interaction was commonly mentioned by participants.

In general, participants agreed on the validity of scenarios mentioned in each concept. Based on that, participants were able to identify and mention new scenarios where the robots can enhance social connectedness and communication in general. For example, one of the new scenarios suggested by participants was about the communication between lecturers and students regarding their communication for before- and after-class events such as discussion clubs, guest lecturers, pop-up meetings, and study groups. In this scenario, students suggested that social robots can announce news and updates about these events and connect teachers with students.

Another important result based on the collected responses was that robots were found to be highly promising in terms of their potential to interact and connect with the students in the campus. There was a general agreement in participants' responses that robots would be highly engaging and connecting people in the campus in different ways and with different forms of interactions.

Natural interactions and design

As mentioned in previous chapters and also above in this section, naturalness was determined to be an important part of design. Noting this while analysing the results, participants showed a positive perception of simplicity and naturalness in interaction as well as the design of social robots. For example, one of the participants mention that the fact that design of these robots does not include a mounted display or similar digital screens

attached to robot's body would make users interact in natural means (via speech, gestures etc.) Similarly, most participants responded positively to embodied design and robot's characteristics that guide the user in the interactions.

Another response on the design indicated that in Concept III, interaction with the robot Drobo would be natural and easy. This was due to the fact drones are already robots that people are familiar with and that while they are in the air they can rapidly and automatically adjust height and proximity to prepare for interaction. Others agreed on the naturalness of Concept I and II and stated that their design by default includes natural qualities and thus a natural interaction is expected.

5. DISCUSSION

In this chapter, we present the findings of our study and discuss these answering to the research questions of the thesis. First, we present the main findings by addressing the research questions. Second, design implications and challenges based on the pre-study and user evaluation results are provided. Lastly, we discuss the limitations of the study with suggestions for future research.

5.1 Main findings

In this section we address the research questions of our study with a summary of the findings. As initially planned in research process, in order to answer the research questions, we focused on the following goals:

- ***Identify scenarios about how social robots could be used in social context at university campuses with a focus on social engagement:*** From the pre-study in Chapter 3, we identified scenarios for students and other potential users in the campus on how social robots could be used with a focus on social engagement. These were mainly based on observations and interview results as part of the pre-study.
- ***Develop concepts for a communication model where social robots are used as mediators:*** Using the data collected in the pre-study, a thematic content analysis was conducted. This helped us gathering design implications and considerations for the concepts introduced in Chapter 4. In total, based on the identified implications, we introduced three different concepts with social robots as active communication mediators.
- ***Conduct user evaluations for the concepts with target audience:*** Lastly, a user evaluation questionnaire was conducted with 10 participants to evaluate the introduced concepts.

Our findings can be further discussed and distributed under the research questions below as follows:

RQ1: How can social robots be used as social mediators of communication at university campus?

This first question is rather broad and therefore we studied it as a set of more specific sub-questions. According to this we first looked at the areas different user groups can

benefit from social robots in communication with regards to social engagement. Pre-study, observations, and user evaluation questionnaire revealed many areas where the users can achieve higher social engagement. For example: the communication between lecturer and students, student's engagement with any other entities, as well as the social events these parties could be involved are all potential areas where the university residents can benefit from social robots. For this, we found that "connectedness" of social robot with it's social surrounding is essential here. This is why the robots should be accepted and integrated in the environments they are part of. For example, as suggested in one of the concepts, social media and internet connection and interaction with students via these can contribute to the communication.

In order to realise the potential of social robots, certain design attributes are required. As also found to be an important design attribute according to results of earlier studies, embodiment was found to be one of the most important design attributes in our study. We also present other design attributes that should be adopted for achieving social engagement.

RQ2: How can communication and social engagement be enhanced using social robots?

Our observations and pre-study results show that students have a positive attitude towards social robots as well as their usage in the campus setting. The concepts introduced in our study can be considered as potential ways to enhance communication and social engagement. Also, in the user evaluation process, after the concepts are introduced to participants showed their interest towards the suggested use cases and scenarios. Furthermore, participants suggest new methods and scenarios in their responses to user evaluation questionnaire which are directly from the target user group.

As presented in Chapter 3, there are certain design characteristics and attributes desired by the users and these should be considered in designing social robots and concepts of social interaction. Among the themes we developed, especially ease of access, mobility, and user friendliness could have a positive (also negative if not done correctly) effect on the communication with social robots and thus on social engagement, as well. Our study shows that social robot's potential can be fully enabled depending on how well these design attributes (themes) are adopted in design.

RQ3: What makes the social robot and interaction design attractive for constructive communication?

In order to answer this question, we look at the views and responses of respondents in both pre-study and user evaluation steps. In pre-study participants share the qualities of

their ideal social robot design with which they would interact and connect. According to this, humanness, simplicity, and user-friendliness are found to be the main attributes that can make the design more attractive. It should be noted here that by “humanness” we refer to naturalness of design and human resemblance in the interaction methods. Therefore, the term should not be confused with human-likeness of humanoid robots.

In addition, based on the previous research on this topic and our study, we consider embodiment as a crucial element in design. Embodied design and embodied social robots make the interaction more accessible and attractive, since in such designs, interaction cues are naturally and easily perceivable by users (e.g. facial cues).

User evaluation reveals that concepted social robots are attractive to participants of the study and they are found to be attractive and engaging at different levels. This suggests the design considerations and implications applied in the concepts were generally accepted by the participants.

5.2 Design implications and challenges

In order to wrap up the design related findings from our study and from previous work, in this section we discuss the design implications and challenges. According to this, we propose the following design implications for a social robot which would mediate human-human communication in the campus environment:

1. Robot’s design attributes and characteristics should match its social role and tasks: Robot’s appearance versus its roles and tasks should be carefully considered in design. Designer’s choice of form might conflict with user’s preference or understanding of the role and tasks of the social robot [3, 20] While it was an interesting design to some participants, drone robot (Concept III) was not found as attractive as the human-like (Concept I) and pet-like (Concept II) social robots.
2. Human-robot interaction should be made natural and prompt within design: Natural interactions are almost immediately started without any additional efforts or procedures. As also participants of user evaluation questionnaire stated interactions should be similar to those that they use in human-human communication (speech, gestures etc.).
3. Embodiment is important for user involvement: It is important to have affordances and resemblance to body shape and facial similarity (as in human morphology) to enable user engagement in interaction. In our study, participants were able to discover and guess the abilities of concepted robots based on their appearance.

Once the users are able to sense the abilities, engagement therefore becomes more likely. [58, 61]

4. Robot's should have an engaging design with readable social cues: Social robots should be able to communicate their internal states to users with perceivable cues; allowing users to interact using their face, body, and voice [20]. For example, absence of a digital screen or display as part of robot's body was found to be a positive detail about concepted designs in this study.
5. Robots are mobile and accessible within the right distance and with the preferred method of interaction: Robot's should be available to users at a social distance sufficient to start interaction. In our study, not being limited to a certain place or location for the robot interaction was mentioned as a requirement for ideal interaction. Thus, accessing the robot or the interaction should not take extra effort from the user (e.g. going to specific location, interaction procedure etc.)

In addition to above given design implications, there are also three main challenges to design of social robots. These are discussed below in brief.

Natural and approachable design with human-like interaction without too much human-likeliness (realism)

While naturalness can be a positive design attribute, too much human-likeliness (realism) can be perceived negatively by users. This is mainly due to the uncanny effect [17, 18]. However, with the existing design evaluation methods for social robots it might be difficult to find a balance of human-likeliness and naturalness in designing approachable social robots which are engaging for interaction. User's perception on the design can lead to biased attitude towards the social robot.

Feasibility of physical and conversational interaction

Social robots that are physically present in social spaces might require physical interaction. In general, especially after the global pandemic (Covid-19) in 2020, there has been a growing hygiene concern in all parts of our lives. Therefore, physical interaction is not preferred. For the conversation interaction; before a verbal interaction can be started, user's perception of robot's abilities and intelligence should be constructed. In other words, a user might not be fully aware of robot's conversation interaction abilities before starting the interaction. In certain cases, this might result in not starting the conversation at all, or a hesitance towards starting more complex conversations.

5.3 Limitations

During this thesis study, we had several limitations. We discuss these limitations one by one in this section.

Lack of face-to-face interviewing and user evaluation iterations

As mentioned earlier, during the time this research has been conducted, a global pandemic (Covid-19) has affected the whole world with widespread restrictions. During this time some public spaces were subject to restrictions which limited visits and entrance. For example, contact lectures at the university campus were cancelled and the amount of visitors in campus reduced drastically. As a result, interviews with users could not be conducted face to face. Additionally, the study would benefit from a scenario-based testing and user evaluation with users evaluating a mock-up or prototype in a real campus space and based on the results design iterations and revisions with more rounds of evaluations could be carried out. As we have seen from the user evaluation results, some important attributes such as trust, reliability, and usefulness had relatively lower scores for all three concepts. This could be due to the limitations and bias in the perception of users during. Therefore, additional evaluation rounds with realistic design models or prototypes might help improving the results. Potentially, this could also be a good research topic for future studies.

Hygiene in touch-based interactions of social robots

Due to the Covid-19 pandemic, hygiene became a sensitive topic especially in public spaces. During the pandemic, a general move towards contactless life has taken place. For example, in some areas only card payments were accepted to avoid using coins and banknotes. Similarly, hygiene concerns have been a limitation for having prototypes of the concepted social robots and have them available in public spaces for interaction. As a more general limitation, these hygiene concerns and the risk of spreading the diseases during such times touch based interactions cannot be considered in design.

Design challenges regarding visually impaired and other types of disabilities in social engagement

In our study, we discussed visual attributes and cues as part of embodiment in design. Considering the users with disabilities and accessibility issues, there are a number of limitations in making the design equally engaging and attractive to all users. Similarly, while designing human-computer interactions accessibility considerations should be part of the design, as well as the user evaluation rounds.

Designing for different user groups, cultures, and different segments of demographics

Due to the time constraints and limited availability of different user groups, pre-study and user evaluation were carried out with students and researchers. Especially due to the restrictions, face-to-face meetings and visits in-campus, staff and other user groups such as lecturers could not be part of pre-study or user evaluation process. While our focus was mainly on the student users, considering roles and needs of different users in the campus environment could be highly beneficial in designing the robots with various roles.

Assigning too many roles to a social robot

One of the challenges is considering too many use cases, scenarios, and features supported in a single social robot design. Users usually require visual cues and hints to perceive what could be the features of a design. In order to keep a balance of attractive design with features that responds to user needs, limiting the design with certain roles might be ideal. As discussed in the theoretical background, there should be an agreement between the social form, role and function. Too many roles and features in one design can confuse users and reduce attractiveness, while specific roles and relevant design attributes could lead to natural interactions between the robot and users.

After discussing the limitations of this study, it is also important to consider the future work opportunities in this topic and in general social robotics field for enhancing social engagement and connectedness. Our understanding of what is “social” is constantly being redefined as we adopt to developing technologies and integrate them to our lives in different ways. For example, with the smart phones and internet, we started using the term “social media” and it has become the new way of interaction. As a result, it has changed the perception on what is social and what is not. Therefore, while we discuss social robot’s role and potential in enhancing social engagement, it should be separately studied over time as a separate topic in order to understand the changing definition of socialness and what type of new solutions can be considered for enhancing it.

6. CONCLUSION

In this thesis we look at the ways our social activities and interactions can be supported and facilitated by technology, specifically by socially interactive robots with a special emphasis on the university campus environment. We investigated social robots with a question whether they can have the role for mediating human-human communication. For this, we look at the social engagement in the university campus setting. Additionally, we also investigated how social robots can enhance communication and social engagement. In order to answer these questions, we conducted a pre-study with 16 participants. Pre-study results coupled with observations have been used to identify scenarios for social robot interaction at the university and also to draw design implications via thematic analysis. These revealed the following focus areas design considerations: ease of access, mobility, humanness, simplicity, and user-friendliness.

The results of thematic analysis in the pre-study phase and design implications were used to develop and introduce three concepts for social robots in university campus environment with a focus on enhancing social engagement and connectedness. In each concept we provided a design concept for socially interactive robots with different design metaphors, role, and forms. We later conducted a user evaluation questionnaire with 10 participants using the Robot Attitude Scale and open-ended questions. Overall, the results showed that all concepts were found to be attractive and participants accepted the design recognizing their potential to mediate the social connectedness and communication. Also, the effect of embodiment on user's perception and approach towards social robots was found to be positive. Additionally, new scenarios and use cases such as mediating teacher-student communication, contributing to lectures, sharing lecture updates were suggested by participants during the evaluation phase which can be considered in future research.

Based on the previous work in this field, our pre-study and user evaluation questionnaire results, we gathered and provided a list with five design implications for social robots which can act as mediators in human-human communication and connectedness. For future, we believe that it would be beneficial to design concepts and social robots with these design considerations to be further evaluated with physical prototypes and face-to-face interviews with actual users. We believe, social robots with such embodied design attributes and social roles can attract people to engage with first the robots and through the robots connect and engage with the rest of society.

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APPENDIX A: INTERVIEW QUESTION TEMPLATE

Age:
Nationality:

1. What do you do when you need to get in touch with someone in the university?
e.g. Student groups, staff, teachers, other students...

2. How do you give feedback and through which channels?
e.g. Email, phone, face-to-face...
    a. Which one of these methods is more convenient to you? Which one feels more comfortable?

3. Do you find it difficult to communicate with other students? What about management and staff?

4. What do you think could help in communication to increase social engagement in the campus? (civic engagement)

5. How do you feel about technology (solutions) being part of this ecosystem?

6. How would you feel about social robots being mediators of communication in the campus?

7. Do you think social robots could help improving communication or support the social development in the university environment?
    a. If yes, how could it be possible?
    b. If no, why wouldn't it be possible?

8. Does it feel same/different when you use different methods to communicate? How?

APPENDIX B: ROBOT ATTITUDES SCALE (RAS)

Study:	Date:
Participant:	

Instructions

Please circle the number that best corresponds to how you feel towards the robot you are about to interact with. Don't think too long about each statement. Make sure you respond to every statement.

I think the robot will be…

unfriendly	1	2	3	4	5	6	7	8	friendly
useless	1	2	3	4	5	6	7	8	useful
untrustworthy	1	2	3	4	5	6	7	8	trustworthy
fragile	1	2	3	4	5	6	7	8	strong
boring	1	2	3	4	5	6	7	8	interesting
basic	1	2	3	4	5	6	7	8	advanced
hard to use	1	2	3	4	5	6	7	8	easy to use
unreliable	1	2	3	4	5	6	7	8	reliable
dangerous	1	2	3	4	5	6	7	8	safe
complicated	1	2	3	4	5	6	7	8	simple
unhelpful	1	2	3	4	5	6	7	8	helpful
uncontrollable	1	2	3	4	5	6	7	8	controllable

APPENDIX C: USER EVALUATION QUESTIONS

Gender: **Age:** **Nationality:**

Status: Student/Graduate/Researcher/Staff

Date:

Questions:

1. Do you think the social robots in the introduced concepts can help in human-human communication at the university campus?
    a. If yes, which robot and concept?
    b. If no, please explain why not.

2. Can you relate to any of the use cases or scenarios considered in these concepts? How do you imagine yourself as a user in those?

3. Do you think the concepts and robots address the real need in social engagement of students or people in general? If not, how can it be improved?

4. Which social robot you consider to be more promising in terms of its potential to enhance social connectedness and engagement?

5. Which social robot are you most likely to interact with? Please explain why.

6. Would you actively interact with these social robots comfortable if they were in the campus and available?

7. Please share your opinion freely on each concept and social robot design.
    a. What do you like or dislike?
    b. Would you change anything if you could?