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DESIGNING PLEASURABLE ROBOTIC EXPERIENCES TO SUPPORT CONNECTEDNESS FOR SEMINAR ATTENDEES

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ABSTRACT

Nasim Beheshtian: Designing Pleasurable Robotic Experiences to Support Connectedness for Seminar Attendees.
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People attend seminars to get to know other individuals in the field and gain expert knowledge while networking and socializing. Although networking is beneficial to build a relationship with others, some people find it to be challenging. The challenge is in the fact that not everyone contributes to conversations or they are too shy to approach strangers and break the ice.

There are different ice-breaker solutions developed to make the process easier for event attendees to socialize with unfamiliar people. For example, there are wearable technologies available that use proximity sensors to connect people with similar interests at events. Mobile phone applications are also very popular to use and make it possible for event attendees to connect before or after events. Similarly, interactive tabletops can also be ice-breakers and assist people to connect through multi-user interactions. However, social robots have not been studied in event context, although previous work has shown that they can be used as facilitators and mediators for connectedness in general.

In this thesis, we have used a social robot called Pepper to study how robots can act as facilitators of social connectedness among strangers at events and create pleasurable and positive user experiences for event attendees. While there has been few earlier research in social connection using virtual assistants and social robots, physical social robots have never been studied as facilitators of connectedness at events.

In order to identify if social robots can act as facilitators of connectedness, and create pleasurable and positive experiences for seminar attendees, we have conducted a pilot study and two field trials with overall 55 participants. In our pilot study (n=12), our goal was to gather feedback from university staff and students on the topic of social robots as facilitators of connectedness. In the field trials, we gathered information and feedback from the target users on the two concepts we implemented in the Pepper robot to address their needs and requirements. The concept for the first field trial was a Welcoming application to give information on the seminar. And the second concept for the second field trial was a simple two player game for event participants to play and connect to each other. In the first field trial (n=31), we took insights from our pilot study and conducted a field study with seminar attendees to gather feedback from the real users on a Welcoming application. For the second field trial (n=12), we created a prototype of an interaction concept called Color Game based on the feedback gathered from the earlier studies, and evaluated it at an event. The empirical research of this thesis includes surveys, interviews, and observations through qualitative and quantitate methods of data gathering and analysis.

The findings suggest that social robots have the potential of becoming facilitators of connectedness at events, and participants had mostly positive and pleasurable experiences evoked by social robots and concepts during the events. Social robots can become acceptable ice-breakers at events by providing the attendees with fun and entertaining activities, such as games. Most participants expressed having fun and joyful interactions with the robot, and their experiences with the evaluated applications were positive . Positive experiences made it possible for attendees to accept social robots as ice-breakers and as means to connect and become familiar with strangers during events.

Although in the study we found out that the majority of participants were interested in social robots, it is important for robotic platforms to follow certain guidelines to create better interactions and experiences for users. Thus, we have created a list of design implications, which can be used for future developments of social robotic as ice-breakers at events, and also to contribute to the field of human-robotic interaction.

Keywords: Human-robot interaction, Social robots, Social Connectedness, Ice-breaking Technologies, User Experience

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

PREFACE

“Everything is designed. Few things are designed well.”

Brian Reed

I was always interested in robots, and by doing this thesis I got to realize I had little knowledge about them. By doing research for my thesis I got to read many informative and interesting scientific studies, which helped me to learn a lot about human-robot interaction field. I am so thankful to be given this opportunity by Aino Ahtinen and Virpa D to work with social robot Pepper and learn a lot about human-robot interaction.

Throughout this thesis, I was challenged positively to do my best to do research and learn a lot of hard work along the way. I had the opportunity to talk with many highly educated people in various fields and gain knowledge about their research. I am hopeful that the experience I have gained in this thesis will help me in my future professional career.

I am grateful to my supervisor, Aino Ahtinen who gave me the opportunity to work on this thesis and guided me throughout the whole process. I have learned a lot from her concrete and valuable comments and feedback. Her positive energy gave me the motivation to push myself and perform better in my research. I would like to thank Virpa D and SYK Oy for providing the funding to work on this thesis. A big thanks to Aleksi Hiltunen for helping me a lot in implementing the robotic concepts for my thesis, without his help it would have been very difficult to perform the user studies. I would like to thank Kirsikka Kaipainen for giving me helpful comments and feedback whenever I needed help, and for being my second examiner in my thesis. I want to thank Kalle Kähkönen for providing me with the opportunity to take part in writing a paper related to my thesis. I would like to thank Aparajita Chowdhury for her help during my first field study, and helping me in getting to know Pepper’s functionalities in the beginning of my thesis.

I would like to thank my family who have always supported me and were by my side in my studies. I would like to thank my husband Pouya Eghbali who has always believed in me and gave me positive energy to move forward in life.

Tampere, 11 April 2019

Nasim Beheshtian

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LIST OF SYMBOLS AND ABBREVIATIONS

HCD	Human-centered Design
TUT	Tampere University of Technology
TWR	Transdisciplinary Workplace Research Seminar
RAS	Robot Attitude Survey
HRI	Human-robot Interaction
TAM	Technology Acceptance Model
UX	User Experience
UEQ	User Experience Questionnaire
UEQs	User Experience Questionnaire short version

1. INTRODUCTION

This chapter explains the topic of the study, which is social robots as facilitators of social connectedness at events. In addition to the reasons behind studying this topic, this chapter will also cover the motivation behind it, and how the thesis can be helpful to the field of human-robot interaction.

1.1 Background and Motivation

We have attended different types of events in our lives such as parties, weddings, corporate gatherings, conferences, and seminars. Unlike weddings and social gatherings, seminars and conferences provide professionals with a chance to meet likeminded people and to get to know other people active in the field. According to a study done on people's attendance and connections at events [1], most participants stated, the main reason they participate in a conference or an event is to network with others. Networking can maximize significant amount of learning by connecting individuals from wider organizations [2]. Therefore, networking plays a major role in the context of events. Although *networking is beneficial for a person's career*, many people are not comfortable with the idea of it. Firstly, people may find networking intimidating or challenging [3], they might have low self-esteem, or they cannot meet the right person at events [1]. Secondly, people prefer to talk to those who they are familiar with. However, it is beneficial to approach people in events, and get to know others in order to expand our network and get to know others in the field [4]. As networking is considered to be one of the important aspect of human's life, people who do not take advantage to connect and network with others will fall behind in today's competitive and global environment [5].

In addition to networking aspect of events, the event organizers need to create events, which *provide the attendees with novel and exceptional experiences*. Thus, it is required for the organizers to organize the events in ways that can become *memorable and personal* for attendees [6]. Attendees participate in events because they want to fulfill certain needs and benefits. Hence, a greater involvement and engagement will increase the chances of an unforgettable experience [7]. Moreover, ensuring the visitors' delight, education, relaxation, and emotional attachment can strengthen the memorability for users [8]. There are different types of solutions available to make the networking process more

accessible and comfortable for attendants at events [9]. However, one negative aspect of these systems is the lack of trust and concern over *privacy and security issues of sharing information on networking solutions* [10]. Some people prefer to talk and connect to others only face-to-face, instead of using these devices.

To overcome the privacy and security issues associated with the current technological solutions, and in order to provide a novel experience for seminar attendees to get to know unfamiliar people at events, we have selected *social robots as ice breakers and facilitators of social connectedness at events*. Social robots can attract people to gather around and encourage interaction [11] while simultaneously enabling the use of the platforms available on the robot to connect to others more easily.

We used a social humanoid robot called Pepper [12] as an ice-breaker in this study to attract people to interact with it. Pepper is capable of recognizing peoples' faces and human emotions, and communicating with people through speech and a built-in touch screen tablet. With more than 2000 companies all over the world, buying and utilizing Pepper as a guide and assistance [12], we hypnotized it is possible to assign a new role to Pepper as an ice-breaker and facilitator of social connectedness at events. Part of the reason in choosing Pepper as facilitator of social connectedness is the human resemblance element, multimodality, variety of hand gestures, and smart capabilities such as face detection, voice recognition and emotion detection. Additionally, social robots such as Pepper, which appear human-like to a certain degree, are proven to be *more welcoming to people to interact* with [13].

The overall aim of this thesis is to introduce a *novel way of social connectedness among strangers at events.* We are aiming to enhance human connections through social robots by implementing ice-breaking robotic concepts that can create pleasurable and positive user experience for event attendees. These days social robots are entering our lives more than before, and it is beneficial to human robotic developers to study areas of robotics that help to understand how people are willing to accept these robots easier and better. This way science of HRI can benefit from research findings to implement useful and acceptable robotic platforms. In this study, we assigned a role of ice-breaker to a social robot and studied how it could facilitate connectedness among people who were unfamiliar with each other at events.

The topic of social robots as facilitators of connectedness has been studied before in connecting young adults who live alone [14], also in a study where the researchers observed people started socializing after interacting with a social robot [15]. Additionally, a virtual social robot was used in a study to connect people at a conference [16]. However, to our knowledge*, the use of a physical robot such as Pepper has never been studied in the context of human connectedness at events*. We have utilized the *human-centered*

design (HCD) approach [17] to examine the users in the authentic environment and ask their feedback on our topic of study. Moreover, by the use of HCD we were able to design concepts (design ideas) [1] that satisfy users' needs and desires in interaction with social robots. We have also used *constructive design research* [18] approach in this study. The constructive design research is about processes that are involved in creating concepts [19]. The reason this approach is selected is because this thesis includes processes that lead to creating concepts that can help to explore the factors that can have roles on social robots facilitation of connectedness in events; and also to form design implications to enhance the robotic experiences for seminar participants.

It is worth mentioning that the role of the author of this thesis was to ideate and design robotic concepts, conduct user studies, analyze user studies results and report the findings. The implementation of the concepts throughout this thesis was done by a software developer who worked on the implementation of the concepts as his part time task.

1.2 Research Objectives and Research Questions

The topic of social facilitation with the help of robots is quite new, and there is limited research conducted in this area [20,13]. Therefore, there is a research gap that this thesis aims to address. By being able to respond to the research questions listed in this chapter, we contribute to the field of human-robot interaction (HRI)[1] – the study of interaction between a human being and a robot – and help people to use social robots as new ways of connecting to others at events. Additionally, the results of our study can provide new and valuable insights into the field of HRI, which can be used by seminar organizers and robot developers to enhance the robotic experiences they provide.

Research objectives: The general objective of the thesis is to explore social robots as acceptable facilitators and ice-beakers at events and to find out how they can contribute to human connectedness at events. Moreover, the objective is to study how social robots can create pleasurable and positive user experiences for seminar attendees. Our final aim is to design concepts that can address user needs and expectations, and form design implications to be used as guidelines in the future field of human robotic research.

[1] https://en.wikipedia.org/wiki/Concept

Research questions:

1. How can social robots act as acceptable facilitators of social connectedness for seminar attendees?

2. How can social robots create pleasurable and positive user experiences for seminar attendees?

3. What are the design implications for robots as acceptable facilitators of social connectedness at events?

1.3 Structure of the Thesis

Chapter 2 goes through the literature review related to the topic of this thesis. It starts by covering the topic of events and seminars, explaining briefly about the social events, and significance of networking and connection to event attendees. Additionally, this chapter focuses on the topic of social robots by defining and providing examples of these robots. Chapter 2 also explores the topics of user experience and user acceptance in the field of robotics. Chapter 3 describes on the research approach, process, phases and methods utilized for the empirical part of this master's thesis work. Chapter 4 focuses on the pre-study (the pilot study and the first field trial) phase where we explored how social robots can act as facilitators of social connectedness and got feedback from seminar attendees on this topic. This chapter includes data gathering, data analysis methods, and the findings of the pre-studies. Chapter 5 includes an interaction concept design developed for the second field trial. More precisely, this chapter identifies the description of initial ideas for the interaction concept, the data analysis and findings of field trial two. Chapter 6 covers a list of different design implications gathered from user studies and literature review. Chapter 7 is allocated to discussion and conclusion. The research questions are answered and summed up in chapter 7. Moreover, the validity and reliability of the findings from the empirical studies is discussed in more detail and the limitations are also discussed in this chapter.

2. LITERATURE REVIEW

This chapter includes a literature review on four main subjects related to this thesis. The first part (2.1) focuses on social events, networking at events, ice breaking activities at events and finally the current technologies available for assisting people to connect to others at events. The second part (2.2) explores the topic of social robots with definitions and examples of them at events context. The third chapter (2.3) explores the topic of user experience in HRI field, and the fourth (2.4) focuses on user acceptance of social robots. The relationship of these concepts to the thesis and their detailed contents are provided in the following chapters.

2.1 Social Events

In this part of the thesis we cover events and their definition along with the importance of meeting and socializing with others during events. The chapter continues with explaining the use and benefit of using ice-breakers during events. Furthermore, we will introduce several research and commercial ice-breaking solutions, which can be used during events.

2.1.1 Events' Networking and Icebreaking Activities

Events can either mean social events where people gather around to meet and connect with each other, or it can mean informal events where people gather with friends and family to enjoy a close social gathering. This thesis is focused on the context of seminars as events. Seminars are defined as meetings, which are organized in order to inform a group of people about a specific topic, or to teach specific skills [21]. There are usually single or multiple speakers, and most of the time the participants are grouped together in a same place [22]. By attending seminars, people can improve their communicational skills, gain expert knowledge, meet others with similar interests, or merely socialize and make new contacts [23]. Socializing at events can be beneficial in different ways. For example, people can network with co-workers within the same field and accomplish work more successfully. People can network with diverse group with whom they get the chance to share ideas, information and learn a lot from each other [24].

Role of ice-breaker activities in networking

Although networking can be helpful, some people find it challenging and uncomfortable. There are people who may feel shy, or might be introverts who do not find it comfortable to approach strangers and start talking to them. Additionally, some people believe they might not have much to contribute, or they might face some difficulties and challenges in talking to unfamiliar people [25]. The social embarrassment and self-consciousness can lead to a negative atmosphere and it can affect the enjoyment and experience of people attending the event [26]. Event organizers mostly utilize various ice-breaking activities to overcome networking challenges, and to make the process smoother for people who are unfamiliar with each other at events. *Ice-breakers* are defined *as tools to decrease tension, social awkwardness and to support people to perform social skills in environments where strangers gather to collaborate and socialize* [27]. An ice-breaker can be in different forms, for instance it can be a mobile game targeted to break the ice among strangers at a social event [26]. It can be in the form of wearable solutions, which can reveal similar interests among strangers attending a conference [28], or it can be in the form of interactive tabletops that enable multi-user interaction among strangers at a conference [29].

Previous research [30] has shown that ice-breakers can result in meaningful connections between people; they can encourage people to participate and create connections by sharing their similar interests and experiences [31]. Ice-breaking activities can create connections among people in different forms. For example, they can provide users with topics of communication or a common place for interaction, they can provide series of activities aimed for people to get to know each other, or they can create a friendly environment and encourage early cooperation and contribution between them [26]. In fact, previous studies [2,32,33,34], have proved that collaboration in the form of games can be an effective way to create social interaction among people (players) who do not know each other. Furthermore, socializing during games has been shown to relieve stress for those who find interacting with others uncomfortable [2]. Similarly, joint activities in games are proven to be promising support for ice-breaking among strangers [26]. Thus, in order for strangers to interact better with each other, applying few elements of fun and joy can enhance their experience, make them relax, and lead them ultimately to interact with each other more comfortably [35].

Furthermore, applying few gamification elements such as different game rules that affect the players' competition to reach the game objective, and enjoyable gameplay can increase the users' motivation and courage to interact with the system. Gamification can increase the value of the product and lead to more user engagement and satisfaction.

Therefore, implementing such elements can result in positive user attitude and behavior. [36]

One example of ice-breaking game is *Who's Next,* which was implemented by Jarusriboonchai et al. [26]. Who's Next was a multiplayer quiz application, which was based on a mobile phone and it was used to break the ice among strangers. The aim of this design concept was to establish collaborative atmosphere among strangers (4 to 10 people) and offer topics for conversations, which led people to connect to each other at the end and talk more. Players start by answering some questions on the phone, which were related to interesting facts about themselves. Next, the game continued with other players guessing the right person behind the answer. The players earned points for guessing the right person and lost points for guessing the wrong person. Six user studies with 28 participants were conducted to assess the social effects and user experience of the game application. The study reported that social interaction was certainly evident by observing the participants having discussions after the game, and friendly teasing laughing and joking during and after the game. The game made it possible for players to be relaxed and open to share with each other topics, which normally do not appear in the first encounter with strangers. [26]. There are different solutions that aim to encourage people to interact and connect with strangers at events more comfortably. The next chapter will cover technological solutions designed as ice-breakers to connect strangers in events.

2.1.2 Technological Networking Solutions at Events

Face to face interaction is proven to be the best way to meet others at events, however initiating conversation with strangers can be difficult for some people [37]. Even though there are some techniques to utilize as conversation openers, not everyone can face the challenge of finding someone and starting a conversation with them. These challenges have led researchers and event organizers to utilize technology for overcoming these barriers [2]. In this chapter we focus on some examples of research and commercial solutions that can act as ice-breakers aiming to enhance and improve the quality of social interaction among strangers at events. Some of the solutions adhere to using wearable technology, while others use public displays, mobile phones and applications.

Wearable technological solutions are one example of research being studied for creating and enhancing social connectedness. One design solution to encourage face-to-face interaction is called *CommonTies* (Figure 1), a wearable device that encourages communication among people who attend conferences and receptions. CommonTies consists of a small, lightweight wristband called a "*tie*" with LED that glows in six various colors. After the registration phase of the conference, each user receives a tie that is

associated with that specific user only. The profiles for each user is based on the information formed from LinkedIn that is being used within CommonTies matchmaker algorithm. The algorithm rates profile of strangers by similarities and matches their ties. People who share similarities will be tied with the same color and they will be detected by beacon so when they locate in close proximity they notice of a match between them and another person. The similarities and interests are based on the context of the event, for instance in a conference, the profiles are based on the registration information, conference proceedings, and talks that users attend. A field study was conducted with 73 users to evaluate face-to-face facilitation through CommonTies at a conference. An online registration form was created where users gave CommonTies permission to their LinkedIn, Facebook, and conference contact lists and papers of interest. Each user had a list of people to match with. The study found that in spite of some minor difficulties in finding the matching person, and noticing the colored beacon, the attendees were overall interested in using CommonTies at the conference. Participants were keen to meet their match, and interact with each other, and overall there was a lot of enthusiasm and willingness from the conference attendees leading them to connect during the conference breaks. [38]

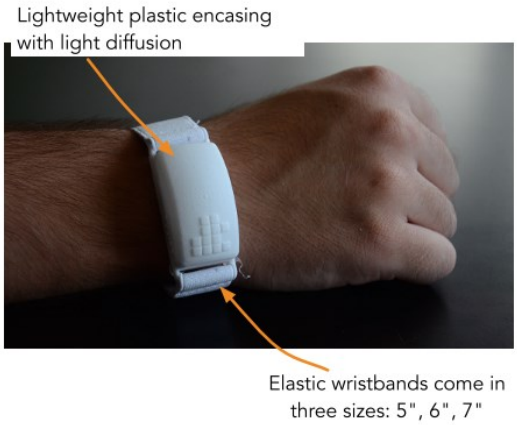

Figure 1. *Sample of CommonTies tie* [38]

Wearable technological solutions are also being used as commercial products in promoting social interaction among event attendees [39]. One instance of wearable technology is *SmartTrac*[2] (Figure 2). It is mostly used for notifying the exhibitors when a potential prospect enters the conference or their booth. SmartTrac consists of two-way "Traco" beacon that couples with proximity sensors to track attendees, and real time updates when the attendee enters the exhibitor's booth for instance. It can also notify the attendees with an event journey report, which displays who they have connected

2 http://www.hubvents.com/device

with, where, and when the meeting took place. It also provides the event organizers data on the interactions and whereabouts of each individual at the event. SmartTrac is still a prototype and unfortunately there are not any studies concerning this product.

Figure 2. *SmartTrac (http://www.hubvents.com/device)*

Another example of wearable technology is *Proxfinity*[3] (Figure 3). It is in a form of a badge that attendees receive when they attend an event. Their contact information and responses to a pre-event survey is loaded to the badge, so when they come within the proximity of another wearer with common interests, the badge sends a signal to the other device. The initials of the badge wearer appear on the small screen on the badge. In order to show a common interest between two people, a colored light in the same corner of both badges lights up. The event participants have also the opportunity to have the recorded locations of the discussion, and settle time for later to do lead tracking. Unfortunately, this product is still in prototype phase and there are no user studies performed on it.

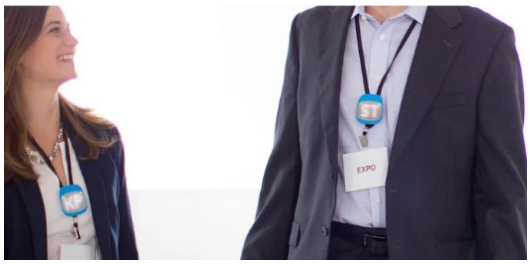

Figure 3. *Proxfinity (https://www.proxfinity.com/technologies)*

Loopd[4] (Figure 4) is another example of wearable technology. It is a two-way beacon, which allows the user to virtually exchange contact information with other people, record details on time and location of each interaction, and provides the event organizer with data from attendees' event journey. It gets activated by touch features that incorporates a yellow LED light from top to bottom. The light serves as a visual confirmation that

3 https://www.proxfinity.com/technologies

4 https://loopd.com/badge

important content have been shared between the attendees and have been placed on the cloud. Unfortunately, this product is also in prototype phase and no user studies have been performed on it.

Figure 4. *Loopd (https://loopd.com/badge)*

Public displays is also another example of technological solutions that can facilitate and improve social encounters. *Ticket2Talk* (T2T) (Figure 5) was a proactive display visualizing a picture of conference attendees along with a caption about their interest for few seconds on a large display. The display also showed a thumbnail of other attendees' pictures whose name tags was detected by the RFID antenna. T2T was designed to be used during coffee breaks at conferences where people have a chance to have conversations and socialize. A user study was conducted at an academic conference with 94 participants; T2T was placed behind the coffee and refreshment tables and the RFID antenna was placed nearby to detect the signal from the attendees name tags. The researchers were hoping for people who stand in line to take their drinks to notice their pictures shown on the display and also notice other close by attendees as well. This way the attendees could have the chance to learn something about people nearby, and start talking with them. The results of the study indicated that T2T was successful in attracting the attention of the attendees and making connection among them. The majority of the respondents attended the conference for the first time, so they found T2T to be very useful in learning something new about other attendees or starting conversations with other people they did not know before. The respondents found T2T to be a good way to break the ice with nearby strangers. [40]

Figure 5. *Ticket2Talk public display and antenna at a conference* [40]

Another example of public displays is *IntelliBadge* (Figure 6). The system was based on RFID and it tracked the conference attendees and analyzed the data in real time and provides the attendees with visuals of the conference attendance, the ability to locate other people at conference, and also the ability to search for events. Since the device had no output all the information was visualized on the large display at the conference. IntelliBadge was tested in IEEE Supercomputing conference with 890 participants who had to carry small RFID tags along with their conference tags. During the registration, the participants were asked to scan their tags and create username and password. Additionally, they were asked to create a summarized personal profile as well. They also had the option of creating a group or joining others in a group and they had to indicate their interests in 10 conference related topics. The participants could use the large displays around the conference to customize their profiles, or use various IntelliBadge services boots. The participants could watch the conference activities as RFID tags showed them on large displays, or interact with the application on the display. The results of the study suggested that participants showed overall interest and positive feedback about IntelliBadge and the large displays. They enjoyed to create groups and get other people to participate in their groups, so some levels of interactions between strangers happened. People were also interested to see how much they walked around the conference compared to others. The displays made many people to gather around and talk amongst themselves and connect. The few negative feedback were about the privacy matters and the whole idea of the study, which some people found impractical. [41]

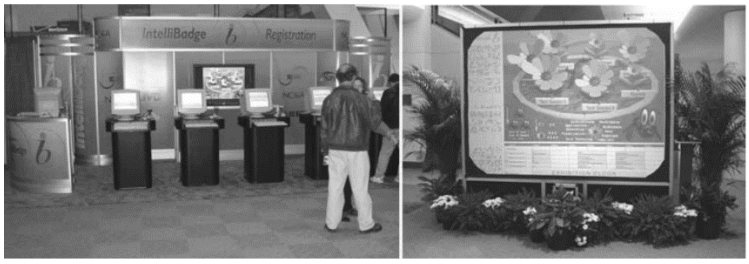

Figure 6. *IntelliBadge registration boot and large display* [41]

Mobile phones are also being used to create and enhance connectedness among strangers at events. Researchers from MIT came up with a mobile phone system that detects wireless devices, links the users profiles, and initiates serendipitous interactions. The system had two applications running on it (Figure 7). The initial application *BlueAware* ran passively in the background of mobile phones and used unique Bluetooth identifiers (BITD) number that mobile phones with Bluetooth transmit when queried. BlueAware recorded and time stamped all the encounters in the proximity log, if it found a device that had not been encountered with before it sent BTID to the Serendipity server. The second application, *Serendipity* queried a server with discoverable Bluetooth identifiers, and created matches with other user profiles. When a person turned on a phone equipped with BlueAware, it automatically started running in the background and notifying the user with a dialog box at a startup showing the matches found for him or her. The user had a chance to read and delete data being collected. The system was tested in a conference, where 40 personal profiles were created on mobiles phones for conference participants. The participants were assigned their phones withBlueAware running on it upon their arrival to the conference. The study showed that the users had mostly positive feedback about such system and they were able to connect with others who they shared similar interests with. However, there were number of complaints about receiving multiple alerts about new introductions while the person was already communicating with another person. Overall, the system was successful to facilitate connection among conference attendees and people were happy to utilize such system to get to know others easier. [42]

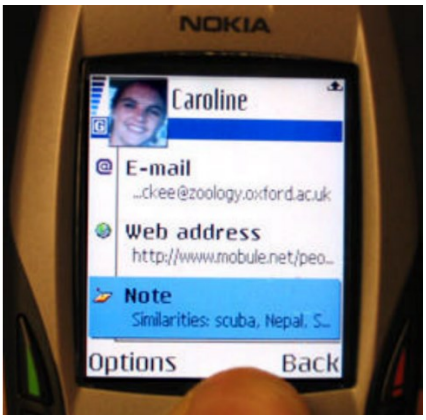

Figure 7. *Mobile phone with BlueAware application* [42]

Mobile applications also play major role in promoting networking at events. Mobile apps can give attendees access to backchannel where they can socialize with other participants and expand their network before and after the event. One of the very useful application is called Brella[5]. The way the app works is that the attendees receive the event invitation on the app, then they write small pitch about themselves for other people to see and read, attendees have the chance of browsing through the app and choose who they want to meet; then they can schedule a meeting with the person they want to connect with. Unfortunately, this product is still in prototype phase and there is not any user studies performed on it.

To summarize the review of research and commercial ice-breaker solutions, it is evident that few factors play important roles when it comes to implementing systems that create connection and social interaction among strangers. It is important for the designed solution to be *easy to use* so people can easily interact with it and use it to its full purpose and connect to others. *Fun factor* is another important element to consider when designing new types of icebreaking solutions. Fun factors make people interested in the device and attract them to use the device more. *Playfulness* is the next factor playing major role in designing solutions that create social interactions. Playfulness can make people interested and curious about the whole concept and engage them in using the system. Moreover, applying few *gamification elements* can enhance the engagement and motivation of users in interacting with a system. Also, the *interactivity of the solution* also makes the system more interesting because people have the option to interact with a system in different ways. Also, it is also important to base the system on the *common interest and mutual topics* among people, which previous research shows can be an important factor for people to connect with each other. *Accuracy and responsiveness* are also important when implementing systems that can be used by busy users such as seminar attendees.

5 https://www.brella.io/

While the earlier discussed solutions can be implemented for creating connections among strangers, our goal in this thesis is to move from traditional solutions to new form of social robot-mediated icebreaker. We have utilized social robots to create social connectedness for seminar attendees and act as icebreakers. Based on the knowledge of the author of this thesis, the concept of social robots as facilitators of connectedness at events is quite untouched and novel. There has been research on social robots as social mediators for children with autism [25], robots for connecting young people who live alone with one another [43], and only one study as facilitators of social connectedness among unfamiliar people [15]. In many cases social robots are designed and implemented to assist elderly people, people who are sick and need daily assistance, to help customers in shopping malls [44] and to guide people in venues [45]. The topic of social robots as acceptable facilitator of social connectedness is quite new and lacks research, therefore the aim of this thesis is to fill this gap, and create opportunity for further research in the future.

2.2 Social Robots

This chapter covers the topic of social robots in general and social robots in the context of events.

2.2.1 Theory and Examples

Nowadays, many robots are being developed to interact with human beings in a society and not only with scientists in research labs. In fact, robots are entering our workplace, our home, medical and educational system. Social robots have the ability to interact and communicate like humans, understand humans, and relate to them [46]. Social robots have social skills that makes them capable of working closely with humans and adding values to their lives by helping, caring, teaching and entertaining them [47,48]. One significant factor in social robots interaction is the embodiment of these socially interactive agents. Physical embodiment includes the body movements of the robot such as the arm movements, postures, and facial expressions during the social interaction. The physical embodiment of robots including their mechanical structures, sensors, and motors are all factors that make it possible for the robots to be part of humans' lives and interact with them in real world. Social robots' embodiment are used as tools for interaction, acceptance, and engagement with human beings. The social robot embodiment should be designed in ways to make the robot capable of generating communicative signals that can be understandable by humans so they relate and accept these robots

easier. The physical embodiment make it possible for the robot to be able to communicate in a more intuitive and human-like way [49].

A robot needs to have specific *communication abilities* in order to be considered a social robot. The robot needs to *behave socially*, and it needs to have the *appearance* that expresses it to be social to the user interacting with it [43]. Therefore, in order for the robot to have an efficient social interaction with humans, it needs to have a physical embodiment close to human beings and it needs to communicate verbally and nonverbally through facial, posture, gesture, nodding, and eye contact [50,48].

Social robots are implemented to be used in research or in some instances to be used for commercial purposes. The following chapter will cover some examples of such robots.

Robots developed for commercial and research purposes

What separates social robots from other kind of robots are their specific skill sets. For example, most social robots are able to communicate with others with high-level dialogues, they can perceive emotions, and they are able to establish and maintain social relationships by using their gaze, and gestures [43]. One example of such robot is NAO [51], developed in 2006 by Aldebaran Robotics. It is designed to be programmed to show complex behaviors and interactions such as imitating human behavior [52]. Another example is Care-O-bot developed by Fraunhofer [53], a mobile robot assistant that continuously supports humans in domestic environments. It has the ability to display various emotions on the display integrated on its head. Another example is a humanoid robot called Pepper, developed by Softbank Robotics, it has the ability to interpret emotions by analyzing facial expressions and tone of voice [12]. Pepper can understand humans' unspoken behavior, and tries to correspond with moods and emotions. According to Kitmann et al. [54], most social robots, which are being used as service and commercial robots are simple and non-manipulating robots, meaning that they are designed for humanrobots interaction purposes and are suited for real world experiments.

Robots developed for research purposes

There are social robots, which are developed for the purpose of research only and their platforms do not offer a lot of interaction possibilities for users. One example of such robots is *Sophia*, a female android[6] robot –a robot designed to resemble human beingsdeveloped by Hong Kong -based Hanson Robotics in 2015 [55]. It adapts to human behavior using artificial intelligence. It has the ability to process the information rapidly and

[6] https://en.wikipedia.org/wiki/Android_(robot)

recognizes voices and faces of humans at the same time. It can express human like facial expressions and human gestures. Another example of a social robot is *iSocioBot*. It is designed to be socially intelligent and to establish durable relationship with its end users. iSocioBot is able to display different facial expressions, and also to move and turn around close to human speed. Moreover, it is able to simulate expression such as listening, thinking, and speaking due to its face and ears [48]. *Erica* is one more example of a more developed robot. Erica is capable of giving natural speech, by giving answers to questions, and communicate with body language. Its eye blinks, facial movements, and head movements are all sign of enhancement in AI in android robots [56].

Regardless of how advanced or basic social robots are designed, their aim is to help and interact with humans in different contexts. In the next chapter we are going to explore the concept of social robots in the event context, and explore how can social robots be helpful to us there.

2.2.2 Social Robots in the Event Context

With the rise of social robots, some industries are moving forward with using these robots at seminars, conferences, exhibitions, or any other type of events. There are some reasons in using social robots in events. For instance, using social robots in an event can be a *new way of engaging with attendees in the event.* It is a good opportunity to *maximize the event experience for the event attendees* by greeting and entertaining the event participants [57]. Additionally, robots can be programmed to be *informative* about the event and *guide* the attendees around the venue by showing the map and directions around the event, and by helping the attendees to browse catalogues, and brochures of the event in an easy and new way [53]. Social robots can be helpful to the event organizers as well. Some social robots are able to scan QR codes, or barcodes and *create databases*, this way they can *register attendees* and *speed up the registration* in conferences or trade shows [57]. Moreover, social robots are *capable of doing repetitive laborious tasks*, and checking in guests *more easily* and *flawlessly* than humans. By providing a *novel*, *unique* and at the same time *easy* and *accessible experience*, the event attendees will remember the event as memorable, so it will lead to positive experiences and reviews for the organizers.

There are few instances of social robots being used at events. One example is *REEM* developed by Pal Robotics [58]. REEM (Figure 8) is as tall as a 170 cm person, weighing almost 100 kilograms. It is being used at events and conferences as a receptionist, *entertainer to guide and greet* the attendees by providing dynamic information and to make presentation and speeches in many languages.

Figure 8. *REEM robot* [58]

REEM has the ability to talk to people in their own language, make jokes, compliment them, help them to find a place, shake hands, and can see the person's face, track their face, and recognize the faces later [59]. It also has the ability to take pictures and upload them on social media such as Twitter. REEM can navigate through a place autonomously and it can be controlled through teleoperation via an android tablet if needed. REEM is able to avoid obstacles and find the shortest path possible for people [55]. There is no information regarding the user experience of REEM in these user studies.

One more example of social robots in the context of event is the Socially Aware Robot Assistant (*SARA)* (Figure 9). SARA is developed in Carnegie Mellon University's Articu-Lab. It is a virtual assistant that can help people by personalizing the interaction and improve the task performance by depending on the relationship between the user and virtual assistant. SARA communicates with the user through a task goal and a social goal. Task goal relates to finding information the user is looking for, and helping the person to navigate through a conference or any other event. As for the social goal, SARA's interaction is comfortable, engaging, and this can lead to a more increased level of closeness and better collaboration between SARA and humans. [57]

Figure 9. *SARA, the Socially Aware Robot Assistant* [60]

SARA was used in two field trials at conferences held in China and Switzerland [60]-[61]. The aim of the trials was to test the functionalities of SARA and evaluate the system with 69 conference attendees. In these conferences, SARA was used in order to help the attendees *find relevant sessions to participate and find interesting people to meet and connect to.* Instead of delivering the information on a textual interface, or plain dialogue, the developers made it possible for people to build relationships with SARA through a multimodal rapport building dialogue, so the conversation was more natural to people [16]. Sara was able to recommend sessions, professional contacts, restaurants, parties, and even leisure activities to the attendees. SARA had access to the database of the conference with the information about the participants, sessions, demos, food vendor, and private parties. It helped with people with *their interest and goals* and then based on the gathered information it was able to recommend sessions and people together. There was no information regarding the user experience of the system in this study.

One other example of social robots in connecting people together is *Fribo* [14]. The main purpose of developing Fribo was to connect together young adults who were close friends but lived alone. Fribo was an auditory information centered social robot that had the ability of recognizing user's activity and analyzing the noise in the person's house and share the activity information with the person's close friends. The noise can be the noise of opening the fridge door, opening the front door, or turning lights on or off. It was mentioned in the study that by sharing the house noise with others, a person felt the need for connectedness with others (Figure 10).

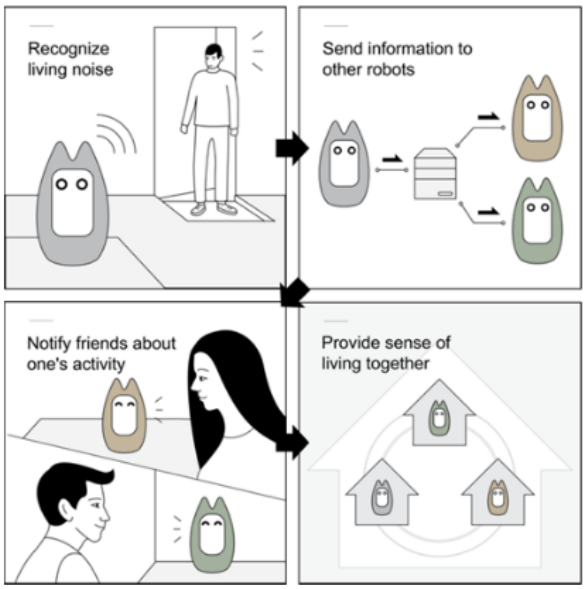

Figure 10. *Fribo sharing living noises with user's friends* [14]

The main reason behind Fribo's design was to minimize the privacy concerns people have with social robots being used in homes. Most robots use cameras to collect data

about people and the surrounding area, Fribo on the other hand, utilizes the auditory information and shares the extracted information of the environment that can overcome the privacy matters people are concerned about. A user study was done with 12 robots being placed at the house of participants between the age of 20 and 30s. The participants were divided in to teams of three close friends, so there were four teams of participants. the aim of the study was to find out if such robot can influence the feeling of loneliness and enhance social connectedness instead. The study found out that sharing the person's environment noise with close friends lead to connecting people together. In the study, some people mentioned they could imagine their friend closing a door, or turning the lights on or off, and felt like they were living together but in different rooms. It was shown in the study that when people imagined their friends' activities, the sense of realism increased for them, and it led to better social interactions between them and others. By sharing the constant information about friends, people said they felt their friend's presence, therefore they felt they had them in their consciousness most of the time. This triggered active interaction between the study participants and led them to have more communication such as phone calls, text messages, and even offline meetings. Increased level of communication between the studies, led to higher level of social interaction and sense of closeness. The study suggests their research contributes to the field HRI by proving that a social robot can be a "*trigger"* in social interaction among people. [14]

In order for social robots to be used in events, and used in different roles such as entertainers, guides, or ice-breakers, it is important for humans to have positive user experience in HRI. Positive user experience will lead to user acceptance of a technology [62], therefore it is useful to explore this phenomena when designing for social robots' concepts. The next chapter will explore some facts about the importance of user experience in interaction with social robots.

2.3 Social Robots and Positive User Experience

Using a new form of technology like social robots at events has to be managed with care to avoid creating situations that have negative impacts on people. The ideal aim is to create an opportunity for people to have positive user experience [63]. User experience (UX) is all about a person's internal feelings and emotions rising before, during, and after interaction with a system, product or a service. Similarly, interaction with social robots can evoke users' emotions and feelings that can affect their overall experience [64]. *If the user experiences the interaction to be negative, it can have negative impacts on using a particular robot,* and it can ultimately affect the acceptance of future robotic

technologies [65]. For robots like any other type of interactive system, positive user experience is vital to achieve intended benefits in human-robot interaction. Creating positive user experience has to be taken in to consideration from the beginning of the design, that is during robotics implementations, UX has to be the center of the design in order to create positive experiences for the users [66,65]. In implementing UX for social robotics, it is important to implement hedonic and pragmatic qualities in the design to create pleasant and interesting experiences for the users.

According to Hassenzahl [67] any interactive system should have pragmatic or hedonic qualities to satisfy users' needs. Pragmatic qualities refer to usability, usefulness, and effectiveness of a system. In designing social robots the *pragmatic attributes* refer to the *level of satisfaction a person has from interaction with the robot, the usefulness of the robot in its roles,* and the *simplicity of the robotic application* [48,64]. As a result, it is important to design robotic platforms to provide the users with easy interactions that can satisfy their expectations, and create positive experience.

Hedonic qualities refer to pleasurable user experiences evoked by interacting with a product or a system. *Enjoyment, satisfaction, fun, and sociability* [64] are all hedonic qualities that a person experiences during and after using a product or a service. *Similarly with social robots, human emotion can be evoked before even the interaction with a social robot begins*. In using social robots in the context of events, it is important to pay attention to the hedonic qualities as much as pragmatic qualities since they can be the deriving factors in inspiring a person to approach the robot and start interacting with it (Figure 11). Moreover, *robot's capabilities such as its characteristics, appearance (animate and human-like), personality, gestures, eye contact, and speech can affect the users' perception of social robots and their experiences to be negative or positive* [67]. Ultimately, *robot's capabilities can affect the hedonic and pragmatic experiences and as a result affect the user's experience to be positive or negative* [65].

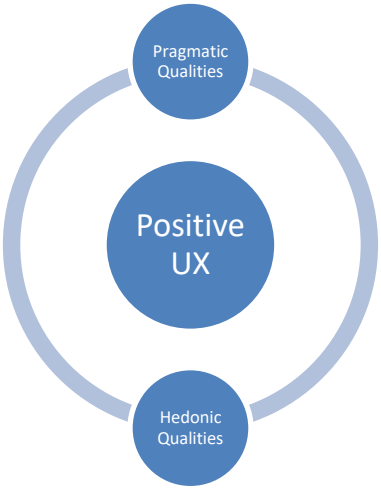

Figure 11. *Attributes leading to positive UX*

By designing for positive user experience, we are hoping to implement concepts for social robots that can enhance the experience of events for attendees. Achieving positive experiences can be derived from providing pleasurable and joyful experiences in human robotic interaction [65]. Positive UX will lead to acceptance of social robots and make people to feel comfortable to interact with these robots [64]. The next chapter will explore the user acceptance variables, which play important roles in human-robot interaction.

2.4 User Acceptance of Social Robots

In this thesis, the aim is to use social robots as acceptable facilitators of social connectedness for seminar attendees. In order to achieve this goal, we need to explore two important aspects in the field of HRI. First, it is necessary to understand what factors influence users to connect and interact with social robots. Second, it is important to consider the process of acceptance from the perspective of the users, this will help in designing robotic platforms that aim to act socially and influence people to interact with them [68]. In short, successful human-robot interaction is related to acceptance of the robots by humans [69].

Technology Acceptance Model

Robots are performing many roles nowadays, and based on research [48,70] they are going to be part of our lives in the near future. In order to invite social robots in to our lives, it is important to understand them better, and explore the reasons that users decide to accept and use robots in their environment. One way to explain social robot acceptance and use is through key acceptance variables.

As there has not been any theoretical model implemented for robotic acceptance yet, most robotics studies apply the *Technology Acceptance Model (TAM) (*Figure 12) [68]. This model might be different in content and complexity, but its goal is to explain variables that affect user acceptance in any form of technology. With the use of TAM, it will be possible to implement robotic platforms, which are more likely to be adapted and used by the end users. In TAM, perceived ease of use and usefulness are the key factors that affect the intention to use a system and the actual use at the end [71].

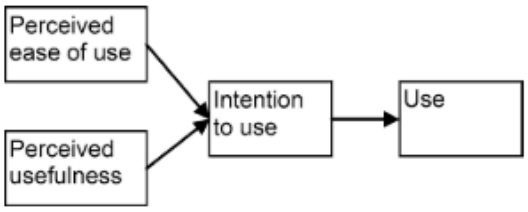

Figure 12 *TAM Model of Acceptance [68]*

User Acceptance Variables

For people to accept social robots, it is important to understand the main key variables of acceptance; these are utilitarian variables, robots' physical appearance and social capabilities [70]. The following paragraphs will cover the details of each variable and their connection to use of social robotics.

Utilitarian variables

There are two aspects in using a product, *Utilitarian* and *Hedonic* variables. Utilitarian variables refer to *practicality* and *usability* of a product. Hedonic factors refer to the user experience of using a product. The utilitarian variables originated from the TAM are *usefulness* and *ease of use*. In the field of robotics, usefulness is described as how users think using the robot in their lives can enhance their daily activities, and ease of use is referred to as the users' belief that using the robot is effortless. *When users think a robotic platform is useful and easy to use, they might show interest to continue their interaction with it* [68,70].

Hedonic variables

Hedonic variables such as *attractiveness* and *enjoyment* have influence on user's acceptance. Enjoyment is referred to as the level of *pleasure* and *joy* a person gets from interacting with a robot. *When a person starts interacting with a social robot and they enjoy their interaction, their pleasurable experience affects their user acceptance*. The other hedonic variable is *attractiveness*. *The attractiveness of a robot is defined as the positive assessment of the robot's physical appearance*. Attractiveness is the most important attribute for the hedonic systems, as it can affect usefulness, ease of use, and enjoyment variables. Creating factors of joy and pleasant appearance in HRI can make

it easier for people to accept social robots and make the interaction smoother [70], [48], [71].

Physical Appearance

It is studied that people *prefer to interact with robots, which appear more human-like*, this will lead them to accept and adapt to robots better in their environment. Robot's human-like characteristics including its appearance, gestures and speech can be designed in ways that people can relate to them, but still distinguishable from humans. It is advisable in addition to the humanoid appearance of the robots, developers consider the interaction between humans and robots. *It is studied that humans prefer to interact with robots with human-like appearances and personalities, therefore they like the interaction to be close to human-human interaction*. [48]

Robot's Social Capabilities

Since social robots are designed to be social with humans, they need to have certain amount of skills. *Sociable robots with effective sociable skills are more pleasant for people to interact with them* [70]. *One way for robots to be sociable is through emotional skills*. According to a general statement by Norman [72, page 7], it is necessary to "*provide people with a sense of satisfaction that they do not feel when dealing with emotionless machines*". When a social robot expresses its feelings and internal emotions similar to humans, it becomes easier for people to interact, and connect with it. Social capabilities and social intelligence of the robot are also important factors in acceptance of them. This can be achieved highly when the social robot is capable of communicating and behaving similarly to humans by using voice and facial expressions, gesture, hand and eye movements [73].

2.5 Summary

In brief, social interactions in events can be beneficial, pleasing, desirable and at the same time challenging for some people [27]. In order to make socializing easier, different research and commercial ice-breaking solutions are implemented to make it easier for strangers to connect at events. Our aim in this thesis is to implement social robots as ice-breakers to help people to get to know others at events, and create positive and pleasurable user experiences for event attendees. But in order to do so, it is necessary to understand how UX is implemented in the field of HRI and what factors are critical in acceptance of social robots in the first place. Since there are not any UX factors implemented for HRI, research studies adapt UX factors implemented in the field of HCI.

Using social robots in events can be a good start to introduce novel and unique ways of entertaining and at the same time connecting the event attendees. *Social robots can increase the event experience by engaging with attendees through joyful, fun and entertaining concepts.* It is the responsibility of the robotic developers and designers to make the interaction smooth and delightful that can lead to positive user experiences. It is important to pay attention to the user acceptance variables and robot's capabilities to design robots application that can attract more people to interact with robots.

3. APPROACH AND METHODOLOGY

This chapter presents the research approach, methods and phases of this thesis work. The first chapter focuses on research approaches and methods utilized in designing and approaching the user studies, the following chapter describes the processes and phases involved in constructing this thesis. The final chapter explain the research platform used on this thesis work.

3.1 Research Approach and Methods

Research Approaches

The first approach of this thesis is *constructive design research* [18]. Constructive design research is about processes involved in creating concepts [19]. The reason this approach is selected is because in this thesis we aim to implement concepts to explore the factors that can have roles on social robots' facilitation of connectedness in events, and also to form design implications to enhance the robotic experiences for seminar participants (RQ3). According to Koskinen et al. [18, page 5] "*in this design approach, construction takes center place and becomes the key means in construction knowledge*". According to Koskinen [16], construction here means anything from prototype, scenario, or a concept that can be built in the future. The purpose of constructive design research is to distinguish problems and factors that might be left unnoticed and implement them in the design [74]. By the use of constructive design research, we implemented one prototype called the Welcoming application in the beginning for the purpose of pre-studies user trials. Next, based on the findings of pre-studies trials, we implemented a prototype of the final interaction concept called Color Game to conduct the second field trial. Finally, we formed a list of design implications for future social robots as facilitators of connectedness at events, which are based on our findings during the field trials and our research.

The second approach applied in this thesis is *human-centered design* (HCD) [17]. HCD focuses on the target user through the whole design process, by examining their needs, expectations and behaviors [75]. The ultimate goal of this study is to explore social robots as acceptable facilitators of social connectedness at events, it was important to move forward with having the users in focus and form all the design and user study factors based on their needs and requirements. Additionally, HCD approach made it possible to examine the users in their own environment and ask their feedback and

insights on the design and coming up with an interaction concept at the end that might please their requirements in interacting with social robots.

There are three phases in HCD [75]. The first phase is called *inspiration phase*, where information is gathered directly from people the product is meant for. In the context of this thesis this phase is done through qualitative and quantitative methods. In the *ideation phase*, the data gathered is analyzed and the opportunity for the future concepts is identified. In this thesis the findings from the quantitative and qualitative methods have been analyzed and lead to ideation for the new interaction concept design for the second field trial. In the *implementation phase*, the concept is developed by putting the target user at the center of the process, and design based on their needs and requirements. The final phase is the *evaluation phase*. In this phase the concept will be tested and evaluated with real users and then evaluated in order to find out how the concept was perceived by the users.

Data Gathering Methods

Qualitative and quantitative data gathering methods were utilized in this thesis. Qualitative method makes it possible to understand the reasons behind various phenomena, whereas quantitative method creates generalizable theories such as statistics data. Moreover, qualitative research makes it possible to evaluate the outcome of the target user interacting with the technology, and at the same time to find out the reason behind their actions, motivations, and feedback [76]. The qualitative data collection methods in this thesis included semi-structured interviews and observations. A free form of observation method was utilized to observe the participants' non-verbal and verbal behavior, their expressions of feelings and their ways of interaction with the social robot.

The quantitative data collection method in this thesis included two sets of surveys to complement the qualitative results and had more accurate and detailed data from the designed concepts for further analysis. One survey used is a 7 point Likert scale and the second survey is Robot Attitude Scale (RAS) [77]. The RAS survey questions were based on a previous research, however the survey elements were altered to match the context of the user study [78].The surveys used in the user studies were short and focused on the key elements in identifying the major factors affecting user's point of view on social robots as facilitators of social connectedness.

For measuring UX in the user study, we

utilized and adapted HCI measuring tool called User Experience Questionnaire short version (UEQs) developed by Hinderks et al. [79] (Appendix J.2). UEQs is an eight item version of a longer UEQ, and it is used in situations where filling out the 26 items of UEQ takes a long time to complete (Appendix J.1). It is proven that using the shorter version

of UEQ is sufficient to measure the pragmatic and hedonic qualities. Four attributes of UEQs belongs to hedonic quality and the rest four belong to pragmatic quality. We used UEQs to measure the experience of the users from interacting with the social robot and the interaction concept (Color Game).

Data Analysis Methods

The content analysis [80] method was utilized to analyze the results of the qualitative data. By means of content analysis we were able to examine the data gathered from the interviews, and observation of the user field trials. The answers to the interview questions were all transcribed and entered in to Excel spreadsheets. For each question a separate Excel spreadsheet was created. After going through the answers, main themes were created. The next step was to create codes for each theme we found, and then matching the codes to each answer. The answers consisting of several parts were divided in to separate sentences in order to have clarity in themes. The frequency of each theme was then calculated and altered in to percentage in order to display a meaningful representation of the data. Finally, for each interview question a graph was created using percentage values.

Content analysis makes it possible to transfer qualitative variables to quantifiable variables that can be understood easier and analyzed [81]. The notes from the observation followed the same procedure as the interview questions. The notes were also analyzed by the use of content analysis and through Excel sheets. During the pre-studies and the second field trial we were able to find total of 64 themes found for observation notes and interview questions (Appendix L).

For the quantitative data analysis, basic statistical analysis methods on Microsoft Excel was used to calculate the mean value and standard deviation for the survey questionnaires, UEQs, and for the RAS survey.

3.2 Research Process and Phases

There were mainly 5 phases included in this thesis that Figure 13 displays the more detailed version of it.

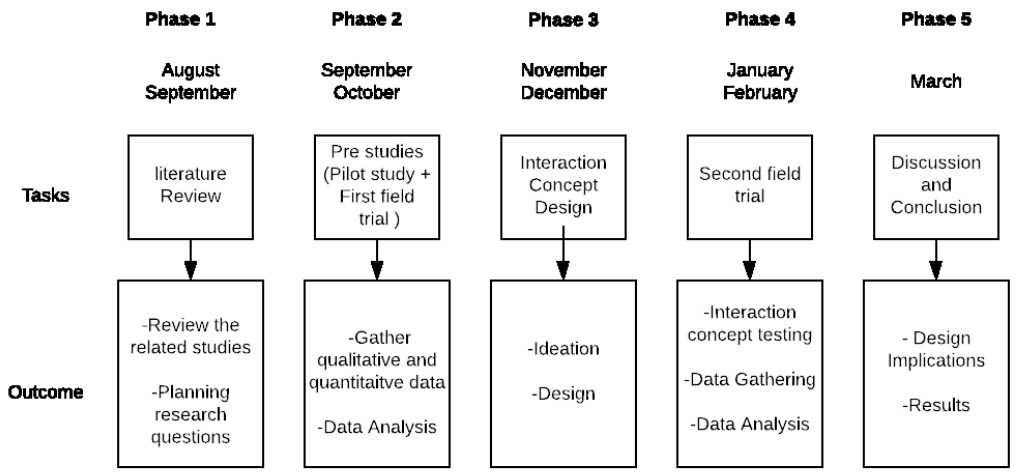

Figure 13. *Research process phases*

Phase 1: Included all the literature review, and the related work studies. This research was helpful in finding information about RQ1, and planning for the next phases. This phase also included forming the research questions and research objectives of the thesis. This phase lasted about two months, however new information and some updates were added to this chapter afterwards.

Phase 2: Included the pre-studies conducted in a form of field study. It contained the pilot study and the first field trial. After the field trial, all gathered data was analyzed and prepared for discussion in a client meeting and developing the next phase (interaction concept). This phase helped in answering RQ1. This phase lasted around two months to be completed.

Phase 3: Included the interaction concept design, which involves ideation sessions, and concept development. After ideating three concepts, and discussing the possible outcome of each in a meeting with the client, the possible design was chosen as a final interaction concept for final user testing, and implementation. This phase lasted for two months and ended in December.

Phase 4: This phase was about interaction concept evaluation and testing. The concept was tested as a field trial and the data gathered was analyzed for the next phase. This phase was helpful in answering RQ2. This phase was over in February.

Phase 5: This phase was the final phase, which included the design implications learned from the literature review, results from pre-studies, and the second field trial for evaluating the interaction concept. It was formed in to a guideline format for future social robots implementation. It can also be used when designing platforms for social facilitation

of robots also. This phase can be helpful in answering RQ3. Discussion chapter will include answering the research question and explaining the lessons learned from doing this thesis. This phase was finalized in March.

Figure 14 displays an overview of four research steps throughout this thesis. A Pre-study (pilot test, the first field trial), design step of the interaction concept, and the evaluation of the interaction concept. Finally, design implications, which included all the important factors needed to take in to consideration when designing for social robots as facilitators of social connectedness. The design implications were the results of the key factors found in the literature review phase, results of the pre-studies, and finally the results of the interaction concept evaluation.

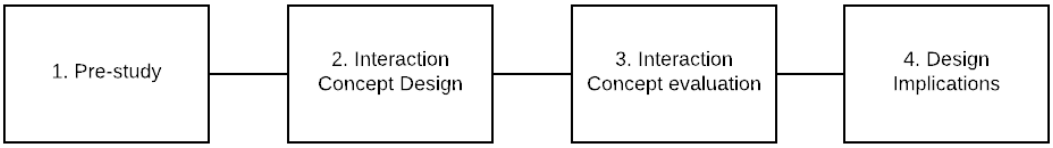

Figure 14. Research steps

This thesis used *field study* through *contextual inquiry* [82] as the main method in conducting user studies. In field studies, the participants could interact with the social robot and the concepts developed on it for the purpose of this thesis study. Field studies made it possible to understand the users in depth, so it could be easier to understand their needs, and behaviors in action [82]. Two pre-studies (the pilot study and the first field trial) and one interaction concept evaluation study.

All field studies were conducted through quantitative and qualitative methods. Quantitative and qualitative methods are important elements of HCD approach as the main purpose of HCD is to put the user in the center of the design process, and understand user's needs and requirements, by gathering data directly from the users themselves [75].

As it is shown in Table 1, the aim of the pilot study and the first field trial was to involve the target users in the study and create an opportunity for them to interact with the Welcoming application implemented on the social robot. Moreover, we wanted to get their feedback on the topic of the thesis and ask about their ideas on the future interaction concept design. The findings of the first two field studies helped in answering RQ1, on **How can social robots be acceptable facilitators of connectedness for seminar attendees at events**.

The interaction concept was designed based on the first studies conducted in the earlier phase, and the overall findings of those two phases. The main objective of this concept was to answer RQ2 **How can social robots create pleasurable and positive user experience for seminar attendees?** The interaction concept design was based on *Human-Centered Design* approach, therefore it aimed to address the target users' requirements, suggestions and feedback in the design.

The overall analysis of the user studies and the information found in theoretical background yield opportunities in designing a design implications. The derived design implications address RQ3, **What are the design implications to enhance the robotic experience for event participants?**

Table 1. Detail of user studies phases

Study Phases	User Study Venue	Study Objectives	RQ Goal	Data Collection methods	Data Analysis Methods
1) Pilot Study	Tampere University of technology	-Involve more members of the target group -Get feedback about the thesis topic	RQ1	-Semi-structured Interviews -Surveys -Observation	-Statistical analysis -Content analysis
2) First field trial: Welcoming Application	Transdisciplinary Workplace Research seminar (TWR)	-Demonstrate the welcoming application -Study the attitude of the target user towards social robots	RQ1	-Semi-structured Interviews -Surveys -Observation	-Statistical analysis -Content analysis
3) Second field trial: Color Game concept	Virpa D Project Event	-Get more feedback from target users -Design implication	RQ 2 RQ3	-Semi-structured Interviews -Surveys -Observation	-Statistical analysis -Content analysis

3.3 Research Platform

Our research objective was to explore robots as facilitators of social connectedness and find out how they can contribute to human connectedness at events. The robot we used in our study was Pepper (Figure 15), the first humanoid robot capable of recognizing human faces and basic human emotions [12]. Pepper can detect both people and obstacles due to its anti-collision system, additionally the robot's 3 multi-directional

wheels makes it capable of moving 360 degrees with a maximum 3 km/h. Pepper has a high definition vision, being equipped with 2 high resolution cameras as well as 3D camera that make it capable of understanding the environment effectively. Moreover, it is also equipped with 20 engines for its head, arms and back. Due to the comprehensive system, the movements are very precise. Pepper was selected as the robotic platform because it can appeal people with its human-likeness, its attractiveness in appearance, its size that is appropriate for people to interact with it, its ability to participate in conversations and, use of its tablet as an alternative means to input in crowded environments [15]. Pepper is equipped with a tablet mounted on its chest that makes it possible for people to interact with it by touch.

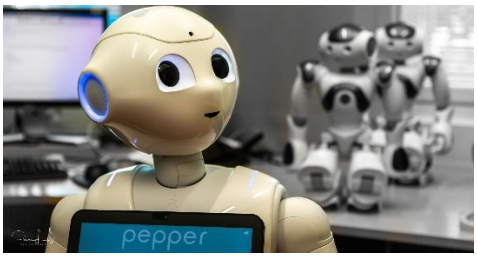

Figure 15. Pepper, the social robot

Ethical Conduct

All the participants attending the user testing were asked to sign a consent form before their interaction with the social robot started. Also, the participants' information or identifying data such as their names, or any other personal data was removed in order to address data privacy. All participants attending the studies were assigned with unique participant number (P#) that separated them from the rest of the participants, and to make it easier and more identifiable for data analysis. The participation in all the user studies was voluntary. All the data gathered from the participants were stored on a computer belonged to the author of this thesis and it was protected with password. The hard copy of the field trial' information including the forms and questionnaires were stored in a locked cabinet in the room of the author of this thesis.

4. PRE-STUDY

This chapter explains the details of the Pre-study conducted in this thesis. The Pre-study included a pilot study and the first field trial. This chapter includes the description of the approach, methodologies, procedures, participant information, and findings from each study.

4.1 Study 1: Pilot Study

The pilot study was conducted in the context of the university. The purpose was to get university staff and students involved in the study, get their feedback and also test the welcoming demo implemented on Pepper.

4.1.1 Methodology

The pilot study was conducted as a field study [82]. The main reason a field trial method was chosen was to conduct the study in user's natural environment and location rather than somewhere unrelated to the study. Moreover, through field study, the moderator can observe the interaction and behavior of the participants better. Also, it is possible for the moderator to get the feedback of the participants in exact context of the study.

4.1.2 Procedure

The pilot study was conducted to involve more people involved in the study, and get their feedback about the topic of the thesis. The pilot was conducted at Tampere University of Technology (TUT), at Tietotalo building for the duration of two hours (Figure 16). Pepper was placed in the hallway during lunch time where there were many students and staff members available and it was a good location for conducting the pilot test.

Figure 16. *Pepper in Pilot Study*

Pepper was presented to people by performing the entertainment features, which were pre-implemented on it, for example dancing, giving hugs, giving high fives, fist bumps, etc. There was also a shopping retail demo that was also pre-implemented on Pepper that was used for people to interact with. The demo was in shoe store, where Pepper demonstrated various shoe options to the user interacting with it and they could choose between models and select the ones they liked. Pepper could assist the shopper in providing information on shoes sizes or colors availability at the store. Pepper was also able to answer basic questions asked by people. It could answer questions regarding its background, and time. The author of this thesis started explaining the test purpose and interacted with the robot first and invited anyone who showed interest to interact with Pepper. People were free to choose any type of entertainment packages they wanted to interacted with.

Data Gathering

The evaluation tools used in the pilot study were semi-structured interviews, observation, and questionnaires. Before the interaction began, the participants were asked to fill out a basic information form and give their consent for the user study. There was a question on the form, which was based on a 7 Likert scale 1 (not interested at all) to 7 (totally interested) to measure the participants overall interest on social robots. There were also short answer questions asking the participants about their prior experience in interaction with social robots, and their previous seminar attendance information, their approach in connecting with others at seminars, and their level of interest in connecting with others at events (Appendix C).

The verbal and nonverbal behavior, and expressions of participants were observed and recorded on free format observation forms by the author of this thesis and a person assisting her at the same time.

The interview conducted was semi-structured (Appendix D), and it took place after the participants were done interacting with Pepper. The author of this thesis asked participants series of open-ended questions. The aim of the interview was to get a deeper understanding of participants' perspectives on social robots, the entertainment features, social robots as guides and icebreakers at events, and finally on social robots in connecting people together at events. The interview questions were used as a tool in providing the means to answer RQ1 *How can social robots be acceptable facilitators of networking and connectedness for people at seminars?*

Data Analysis

For data analysis as described in chapter 3.1, we utilized content analysis to analyze the qualitative data gathered from interview questions and the observations notes. The data was transcribed and entered to Excel sheets for further analysis. For analyzing the quantitative data gathered from the short answer questions, we used basic statistics to calculate the mean and standard deviation.

Participants

Total of 20 people interacted with Pepper and took part in the pilot study. All participants took initiative in interacting with Pepper themselves. Due to the subject of this thesis, the participants had to be people who attended seminars and conferences before; therefore only 12 participants who had prior experience in attending seminars or conferences were chosen for further data analysis. There were 6 PhD students, 2 research assistants, 1 Postdoctoral student, and 3 researchers. Most of the participants (9) were male between the age group of 30-35.

4.1.3 Findings

This chapter includes the findings from analyzing data from the interview questions, observation and questionnaire of the pilot study.

Interest in social robots

Most of the participants mentioned they were interested in social robots. They used terms such as "fabulous", "fun", "amazing", "futuristic", to explain their interest and feeling about social robots. Many people became interested in Pepper's dance and talk, so they approached Pepper to join others and interact with Pepper or just watch others interacting with it. In some instances, it was observed that people even took pictures with Pepper or started to record Pepper on their phones. One person mentioned "*I have to show this*

[Pepper] to my children, so cool" (M, 24-29 years). Some people even showed interest days after interacting with Pepper, by approaching the author of this thesis in the university restaurant and ask about the next user study. One person mentioned he has told about Pepper to his children and they were interested to come to the user testing if possible.

Connecting with others at events

The majority of the participants (9 people) mentioned they were interested in connecting with others at events. One person mentioned "*I like to connect to those with whom I share interests with*" (F, 24-29 years). Another person mentioned "*It depends on the person, if they seem interested in talking with me I talk to them*" (M, 30-35 years). One other person mentioned "*I approach those whom I know, and I don't like to talk to new people, because they may turn me down*" (M, 30-35 years). Even though some people showed interest in connecting to others at events, however there were still those (3 people) who had hesitation in approaching strangers and socializing with them. This might be the reason why many people prefer to socialize with their own familiar circle at events. The findings from this theme was consistent with findings in the literature review stating some people find socializing at events challenging and intimidating for several reasons [1, 3, 4].

Social robot's roles

Many people (9 participants) believed that social robots can be ice breakers in events. Based on the feedback received, most participants believed it is good for the robot to have more entertaining features. They believed entertainment can break the ice easier and make the attendees more comfortable. The participants suggested they were interested to interact with features such as *dance, storytelling, joke telling, taking selfies, and playing games* on Pepper's application. It was found that most people liked the interaction with Pepper, and enjoyed the experience. *Most participants believed social robots can be helpful as guides in events* by for example introducing the event to the audience. One person mentioned "*It [Pepper] can give tours or talk about the event on the stage*", one other participant suggested "*It [Pepper] can guide, but it has to be very precise in guidance, otherwise it can become a boring, and useless experience"* (M, 30-35 years).

Interaction with the robot

It was observed that *many people got interested in Pepper when they saw others interacting with it,* and they approached Pepper after seeing others communicating with it. Some other people just enjoyed Pepper from far and smiled and laughed at its moves.

Few people were scared of the robot in the beginning and once they saw Pepper dancing they started laughing and in some instances dancing with Pepper. Some users *started touching Pepper without paying attention to what the robot was saying*, and *they were interested to see how it was moving its hands and head*. They were few people who *did not show any interest and just passed* by without paying attention to the robot or what was happening around it. *Most people liked the interaction by asking to repeat some of the features again*, for instance they wanted to dance with Pepper in different songs, or play a game on it. Additionally, people were interested to use other applications on Pepper and continue their interaction with it. Some people thought the retail store application on Pepper was implemented for real and it was possible to buy shoes at the store later in Finland. People mentioned they were interested to see social robots around the stores, because it was less awkward for them to ask for help, or advice on buying a product.

Feelings towards the robot

Most of the participants had positive feeling about Pepper. Some mentioned Pepper was “interesting”, “funny”, “cool”, or “attractive”. People generally were happy around Pepper and it was observed that they were smiling and laughing while interacting with the robot. In few instances, there were people who showed feeling of fear toward Pepper. In one example one observer mentioned “*I can’t trust this robot, it is frightening*”, at the same time one other person mentioned “*I can’t wait to see more robots in different venues*”. One other person mentioned “*I have mix feeling about social robots, I think they are creepy and cool at the same time*”.

People’s expectation

The participants mostly believed the entertainment package developed on Pepper was really nice. They were interested to see various kinds of entertainment on Pepper, and spend more time interacting with it. Most people mentioned the entertainment to be *“fun”, “amazing”, “funny”, “attractive”, “wonderful*”. Overall, people had positive opinion about the entertainment developed on Pepper. The only complaint was that there could be more games and dance moves.

Robots as social facilitator of connectedness

As for connecting people to each other, and creating connections among people at a seminar, most *people suggested for the robot to exchange their contact information with other people whom they were interested to socialize and network with*, as one person stated “*I suggest Pepper to give my email to other people who are from my research field”* (M, 30-35 years). Most of the participants suggested that Pepper could introduce

them to other people and guide them to other people from the same field. Some other people mentioned the *best way to connect to others is through entertainment such as games, because people get to spend time talking to strangers and connecting with them*. Overall there was some ambiguity about this topic for some people, because there were some participants who did not have any clear opinion of how such thing could be possible, as one person mentioned "*I am interested to see how Pepper can introduce me to others"* (F, 30-35 years).

4.2 Study 2: First Field Trial: Welcoming Application

The first field trial was conducted at a seminar called Transdisciplinary Workplace Research (TWR), held for the duration of two days at Tampere University of Technology in September 2018. The main purpose of this seminar was to gather international researchers together and create an atmosphere for future collaboration between fields of research. The overall aim of this trial was to test the Welcoming application concept on Pepper with the real target users, and precisely in the context of a seminar.

4.2.1 Methodology

The user study was conducted as a field trial research. A concept called the Welcoming application (Figure 17) was developed on Pepper in order to welcome the seminar attendees to the event and give the schedule of the seminar to them. The main objective of the concept was to use Pepper as an ice breaker for the beginning of the seminars and at the same time do the user study and gather enough data and observation about seminar attendees' feedback and viewpoints on the subject of the study. The Welcoming application included of the seminar schedule, information on keynote speakers' presentation, and workshop locations.

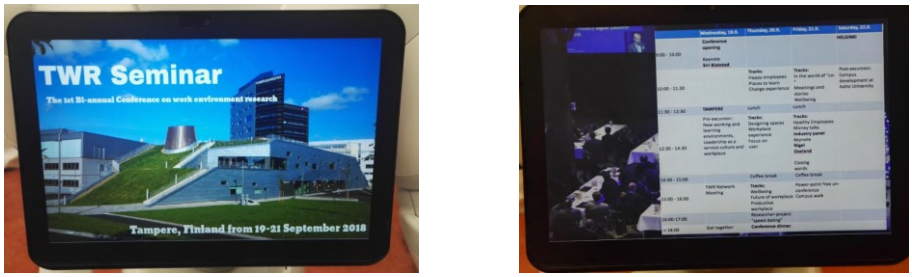

Figure 17. *Welcoming Application*

Moreover, the field trial made it possible for the author of this thesis to get to know the actual users [39], and observe their behavior in their actual environment. It was possible

to observe people and find out how they interacted with Pepper. For instance, observe how they initiated the interaction, or how did they collaborated and communicated during the interaction.

4.2.2 Procedure

The study was conducted at Tampere University of Technology (TUT), and mainly at Kampus Areena building for the duration of the seminar (two days). The seminar attendees were capable of interacting with Pepper through a short and simple welcoming demo implemented on Pepper to welcome the attendees and act as an ice breaker in during the registration of the seminar. The seminar attendees were also able to interact with the entertainment packages pre-implemented on Pepper when the seminar was in break.

During the first day of the seminar, Pepper was taken to Kampus Areena building at (TUT) to conduct the study. The seminar started by registration and by welcoming the attendees through a welcoming application implemented on Pepper at 8:00 - 9:00 am. The application was available through both speech and on the tablet in visual and auditory forms. The participants could interact with the application by inputting their command or through speech. Seminar attendees were invited to interact with the social robot during and after the welcoming demo in order to get them familiar to the context of the study and also to get them familiar with the social robot. The author of this thesis first interacted with the robot and the Welcoming concept in order to familiarize people with the whole procedure, and then invited people to interact with the social robot themselves. People were free to take photographs and videos from Pepper during the welcoming interaction.

Data Gathering

The evaluation tools used in the first field trial were questionnaires, semi-structured interviews, and observation. Before the interaction began, the participants were asked to fill out a basic information form and give their consent for the user study. The participants were asked to fill out a 7 point Likert scale, 1 (not interested at all) to 7 (very interested) to measure the participants overall interest and opinion on social robots (Appendix E). They were also asked about their prior experience in attending a seminar, their previous experience in interaction with social robots, and their interest in meeting new people at events and their approach in meeting new people at event.

The interaction of participants were observed throughout the whole time they were communicating with Pepper, and it was recorded on free format observation forms for later data analysis.

After the interaction with pepper, the participants were asked to fill out an additional questionnaire called Robot Attitude Scale survey (RAS) and answer few interview questions. RAS [77] is based on 8 point scale, and it was utilized to measure the participants' attitude towards social robots after interaction with Pepper. We based this method on the research done previously, which also utilized RAS to measure attitude of the target user towards robots [78] (Appendix E).

RAS consists of 11 item that can predict the quality of the participants' interaction with the robot [83]. The main reason in choosing RAS was to assess the positive and negative attitudes towards social robots. A reduced 10 item version of RAS was used in this study to measure only the relevant attitudes towards the social robot. Items used were (friendly-unfriendly, useful-useless, trustworthy-untrustworthy, easy to use-hard to use, reliable-unreliable, safe-dangerous, helpful-unhelpful, interesting-boring, basic-advanced, complicated-simple).

The interview conducted in the first field trial was semi-structured, and it took place after the seminar attendees interacted with Pepper (Appendix F). The aim of the questions were to find out more about the actual target user of the study's behavior and expectations from social robots in general in the context of the seminar. And to get the participants' opinion and feedback on how they believed social robots could be helpful in connecting them to other people at an event. The interview questions were used as a tool in providing answers to *RQ1. How can social robots be acceptable facilitators of social connectedness for seminar attendees? And RQ2 How can social create pleasurable and positive user experiences for seminar attendees?* The objective was to find out what did participants thought about the whole idea of social robots, and how did they think social robots could be useful in connecting people together while creating better user experiences for them at the event.

Data Analysis

For data analysis as described in chapter 3.1, for analyzing the qualitative data gathered from the interview questions and the observation forms we utilized content analysis and transcribed all data to Excel sheets for further analysis. We used basic statistics to calculate the mean and standard deviation of RAS, UEQs and short answer questions.

Participants

Total of 31 participants took part in the first field trial. Figure 18 summarizes the basic information about the participants in the first field trial. As it can be seen the majority of the participants were PhD students (41%), and researchers (35%) who had the previous

experience in attending seminars. 84% of the participants did not have previous experience with interaction with social robots, and the rest mentioned they had seen social robots in different conference around the world. The participants were interested to meet new people at events, however they only talked to those they were familiar with.

Gender	
Male	8 (26%)
Female	23 (74%)
Age	
24-29	7 (23%)
30-35	10 (35%)
+36	14 (45%)
Occupation	
PhD student	13 (41%)
Researcher	11 (35%)
Other	7 (24%)
Prior experience with social robots	
Few Times	5 (16%)
Never	26 (84%)
Seminar Attendance	
Many Times	24 (75%)
Few Times	7 (25%)

Figure 18. User basic information

4.2.3 Findings

This chapter on includes finding from the analysis of the semi-structured interview, observations, and surveys through the data analysis methods such as content analysis and basic Microsoft Excel to calculate means and standard deviation.

Interest in social robots

The field trial showed *the majority of the participants (70%) found social robots to be interesting and entertaining to interact with*. They showed interest by *taking initiative* and starting the interaction with Pepper. The participants were excited to see Pepper in the beginning of the seminar, and as some mentioned *it was a new experience for them to be welcomed to a seminar*, and they were interested to see *what was the robot doing*. One person who was observing Pepper's interaction with others mentioned "*You know you are in a technical university when you are greeted by a robot, it is a different and nice experience*" (F, 36-41 years) This can indicate that social robots can be accepted as interesting form of interaction for people if they are used as ice breakers, entertainers or guides in general.

Attitude towards social robots

The results from the RAS indicates that participants had mostly positive attitude towards social robots. Based on RAS findings, Pepper was located in the middle or towards the positive side of the scale. The highest ratings on the RAS was on *Dangerous-Safe* (M=6.48; SD=1.36), and *Unfriendly-Friendly* (M=6.42; SD=1.67) attributes. The lowest ratings was on Useless-Useful (M=5.19; SD=1.83), Complicated-Simple (M=5.19; SD=1.73) and Unreliable-Reliable (M=5.06; SD=1.76) attributes. This can indicate that participants had more positive attitude towards Pepper being friendly and safe to use, and less simple, reliable, and useful. This can indicate that the future interaction concept should be easy to use, reliable and useful.

Connecting with others at events

It was also found that *many people are interested in socializing and connecting with others at a seminar,* however they face some challenges in this approach. For instance, some attendees stated "*it can get really crowded, and it is really hard to meet the right person"* (F, 36+ years), *"I really feel shy to approach others"* (M, 36+ years), *"I find it hard to find the interesting person to talk to"* (F, 36+ years), *"I always find myself talking to the wrong people, those who I don't have anything in common"* (F, 30-35 years). This can indicate that people are interested to connect to others at events, however they find it hard to do, this might be the reason that many people prefer to talk with familiar people at events, and ignore socializing with strangers and expand their network. Social robots has to be implemented in ways that eliminate this awkwardness for strangers at events and make it possible for them to connect to those who share similar interests with each other.

Social robot's roles

The study also revealed that many participants enjoyed to see Pepper as an ice breaker and guide in the beginning of the seminar, and this led them to become more relaxed to continue the seminar with a new experience. As one participant mentioned "*I enjoyed to see Pepper first thing in the morning"* (F, 36+ years). Another participant mentioned *" I would have enjoyed if Pepper could register us, so that way the experience would have been much more fun*" (F, 36+ years). Most participants believed Pepper can introduce the seminar to them in to more details. This can indicate that most people are open to the idea of social robots in guides and customer service roles, since welcoming attendees to a seminar is a customer service role for a social robot. Based on the study, it is obvious that people observe Pepper as *a novel way to welcome them to the seminar and maybe register them.*

Interaction with the robot

People in general interacted with Pepper in groups mostly. They became curious if others were gathered around Pepper and were interacting with it (Figure 19) and this caused them to approach Pepper and interact with it or share the feeling of joy and happiness by just watching others dance with Pepper, or give hugs to Pepper. In one occasion the honeypot effect [84] became evident when a passer-by person became interested in people dancing with Pepper, that he also joined and shared his joy with others. Honeypot effect refers to how people interacting with a system can encourage passers-by to observe, participate, and approach in the interaction [85].

Figure 19 *Pepper during TWR seminar*

Many people approached Pepper when it was giving introduction about the event, and took pictures from it, and some even took selfies with Pepper. Pepper was the center of attention whenever the seminar sessions were on break. *People enjoyed interacting with Pepper in groups, for instance three people started dancing when Pepper was dancing. It was observed that people started to talk among themselves when their interaction with Pepper was over*, and even gave comments about Pepper to the author of this thesis in groups.

Feeling towards the robot

The feeling of curiosity and joy was obvious while people were listening to Pepper's welcoming application, or even when Pepper was entertaining the audience. Many attendees commented positively about the whole seminar and presence of Pepper during those two days. For instance some participants mentioned "*Interacting with Pepper was the best part of the day"* (F, 36+ years)*, "Pepper made it not boring"* (F, 36+ years)*, "Seeing Pepper dance was so much fun"* (F, 36+ years)*.*

People's Expectation

Based on the findings, *it was understood that many people were looking to have joyful, entertaining, fun and new experiences with Pepper* (Figure 20).This was observed based on the feedback provided, for instance some people mentioned "*The Pepper dance is so fun to watch"* (F, 36+ years), "*Pepper hugs are very cool"* (M, 24-29 years).

Figure 20. Pepper interacting with People during TWR seminar

Entertainment and fun was the main reason people approached Pepper, and some participants stated the entertainment implemented on Pepper was short and they were eager to see more. Some users suggested to implement a game, challenge, group dance games, or telling jokes concepts on Pepper to make it more fun and joyful. This might indicate that people are more interested to have entertaining interactions with social robots, and implementing games and other fun factors can be welcoming by many people.

Robots as facilitator of social connectedness

In general, participants did not have clear image of how social robots could be helpful in connecting them to others at seminars. Some attendees thought the best way connectedness could be done was through *sharing contact information* with people who they share similar interests with. Some participants shared some implementation ideas for the robot for example as one participant stated "*The implementation should not be childish, it should be implemented in a way that adults get interested in it"* (M, 36+ years), another attendee stated *"The interaction has to be fast, and not slow at all"* (F, 25-30 years). Additionally, many attendees stated that in order to achieve the connectedness goal through social robots, *the robot has to be easy to use and intuitive to interact with*. One participant mentioned "*The robot has to be useful in a way that if it is serving as a guide it gives you the exact response, and if it is serving as a facilitator it needs to be useful*

enough to connect you to the exact people you are looking for" (F, 36+ years) . As it can be stated from the statement the participants were looking for the factor of usefulness in interaction with social robots, and they wanted the interaction to be fast, smooth.

4.3 Summary

Based on the findings from the pre-studies it was discovered that there *is an interest in social robots* in general and *people enjoy interacting with them* even with limited features such as Pepper's. However, it was understood that attributes such as *fun, entertainment and joy* play the most important elements for the participants. Since so many people were looking for to *play games, dance, take selfies with a social robots*, it is important to design concepts that can address the *fun and playfulness* features for the participants. *Group interactions* are the next important feature that needs to be considered. In many occasions, *people showed interest to approach and interact with Pepper in groups*, and they even *continued to talk after the interaction was over*. The main role that a social robot can have in order to facilitate social connectedness is *entertainer*, and *icebreaker*. In many instance participants mentioned, they find it hard to find the right person at events and connect with them, so they were eager to see how Pepper could be helpful in connecting them with other seminar attendees.

On some occasions people commented on the implementation, and technical features of Pepper. For example, it was stated that *Pepper's voice recognition has to be improved* so the user can stay motivated to interact effortlessly with the robot. Additionally, the *face recognition of the robot was another factor that some people believed it needs to be improved*. Many people stated it is very important for *the social robot to have a smooth and intuitive behavior*, so the person interacting with it can understand the robot better, and stay motivated to continue communicating with the robot.

The *overall attitude towards social robots was positive*, this made the participants to have positive experience during their interaction with Pepper. It is important to design and implement the next interaction concept based on the feedback and the data gathered from pre-studies in order to match the users' needs and requirements.

5. INTERACTION CONCEPT DEVELOPMENT AND EVALUATION

This chapter explains the details of the interaction concept developed for this thesis. The interaction concept is designed based on the feedback and results of the data gathered and analyzed from pilot study and the first field trial. The chapter starts by describing the process of developing the interaction concept in general. It continues with exploring the concept's design and description and reporting the results and findings of the user study that was conducted to evaluate the interaction concept.

Figure 21 shows the overall design process applied from HCD approach and refined to apply to our purpose [75,86]. The aim of the diagram is to show the agile development process of the interaction concept.

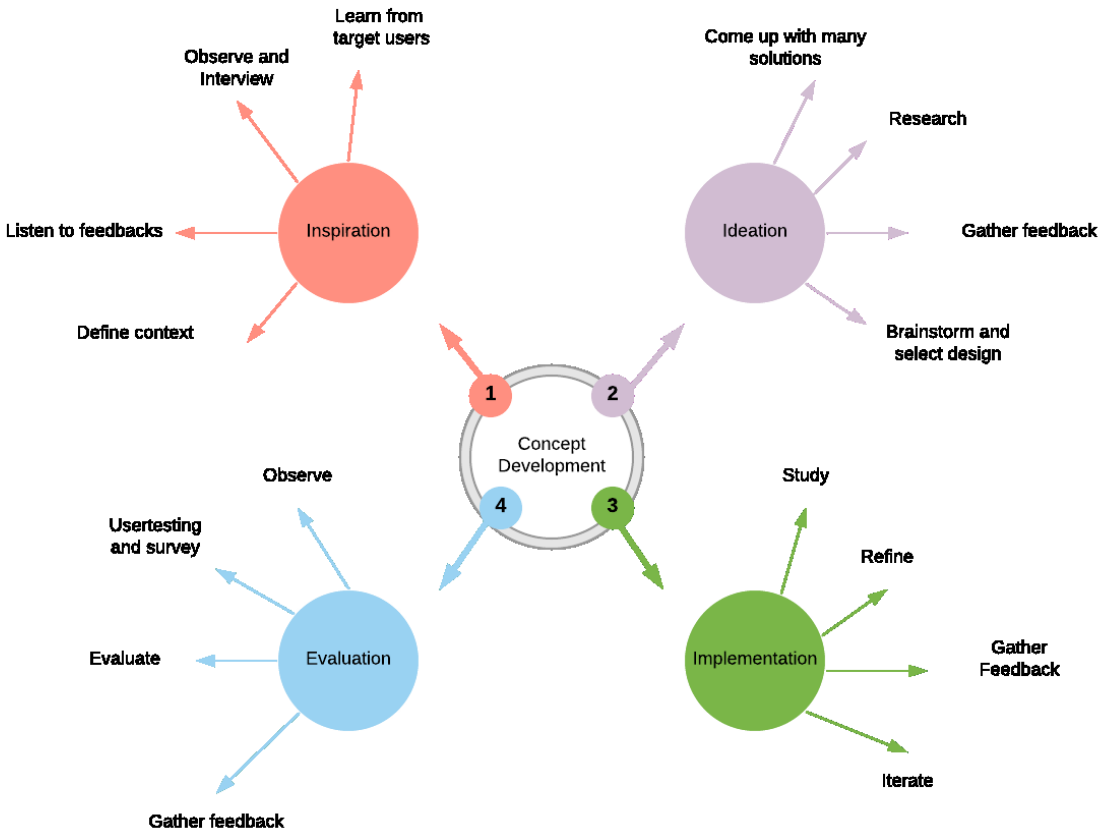

Figure 21. *Interaction Concept development process* [86]

Inspiration: the motivation for interaction concept was formed based on the feedback and data analysis results found during the pilot study and the first field trial.

Ideation: in this step, all the data analyzed from the pre-studies was used to create patterns of what the seminar attendees were looking for in their interaction with social robots. It was found that the participants were mostly looking forward to have fun, entertaining, joyful, new, and playful experiences in their interaction with Pepper. Thus, the ideas for the Interaction Concept was based on these factors in order to convey design every detail on users' needs and desires. Research was done to find out about the different types of networking solutions available to use in events. Based on the feedback received during the pre-study phase, the interaction concept had to be entertaining and fun, therefore the design was based on a concept of a game. Three different paper prototype game concepts (explained in chapter 5.1) were designed to address all the required details the users were looking for. After the ideation and brainstorming was over, the game concepts were discussed among a small group of human-centered technology researchers at the university, and a design with the best potential was selected for further development on Pepper.

Implementation: the interaction concept was then developed as a mid-level fidelity porotype in a form of a game application on Pepper. The game was refined based on research, and some iterations were made after getting feedback from other researchers at the university.

Evaluation**:** The Color Game was presented and evaluated (reported in chapter 5.2) at an event in order to gather feedback and comments on the design, and find out how successful it was in addressing the design goals. The results of the evaluation was then analyzed and delivered in the findings chapter of the interaction concept design.

5.1 Interaction Concept Design and Description

In this chapter, we cover the overall design, and the goals we set for the interaction concept. Additionally, we describe the details of the three game concepts we initially designed, and finally we present the selected concept in to more details.

Based on the findings and the data analyzed from the pre-study phase, we identified three design goals for the interaction concept development of this thesis. Similarly to pre-study, the user group was once again seminar attendees and the context of use was events.

Design Goals:

1. To create a fun and entertaining interaction concept on Pepper for seminar attendees to interact with during the event.
2. To facilitate connectedness and networking between seminar attendees during the event in a novel and creative way.
3. To create a pleasurable and new experience for event attendees based on a new type of ice-breaking interaction concept.

The overall purpose of the interaction concept was to act as an ice-breaker and connect seminar attendees together in an entertaining and interesting way. Therefore, based on pre-studies' findings we decided to implement game concepts that could entertain and connect people at the same time (Figure 22).

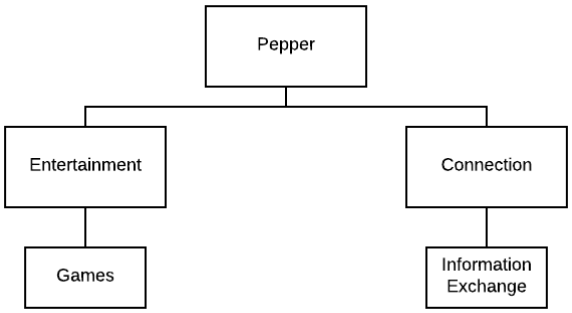

Figure 22. *Concept map*

We started the interaction concept by adapting the HCD approach and putting users in the center of the design process and address their needs and requirements. As a result, three interaction concepts were designed in the form of low level fidelity prototype. The description of each concept is describe in the following chapters:

First Interaction Concept: Games *(Appendix K.1)*

The first concept developed was a game application that offered the participants to choose among three types of games. The games were Tic Tac Toe, Tetris, and Snake. The purpose of the games were to make strangers to play the game, and have fun so they can become more comfortable and relaxed in meeting others at the event. This concept was not chosen for further development since it was decided it could not create a connection between players, and Pepper did not have enough facilitation, and entertainer role in the game, so it will not help in breaking the ice.

Second Interaction Concept: Speed Networking Concept *(Appendix K.2)*

The second concept was called speed networking, and it started by Pepper initiating the conversation with a person at the event. The person had to fill out a basic information form on Pepper's tablet, and then Pepper could match the person with another person's information and recommend them to meet. Pepper then asked the person to use their phones to scan the QR code on the tablet to get the information, and see if he or she was interested to connect to the suggested person. Pepper could also contact the other person by sending an email and ask if she or he was interested to meet and if the answer was positive, at that point Pepper could schedule a time and place for them to meet. This concept was not developed further, since it was not providing the fun and entertaining factors for players, and also it required a lot of time to implement the concept that was beyond the scope of this thesis.

Third Interaction Concept: Color Game *(Appendix K.3)*

This concept was developed as a game where Pepper acted as the facilitator of connectedness to invite people to interact with the game. It was a two player game, which first started by each player choosing four different colors. Each color was associated with a basic personal fact in order to make players to share some information about themselves. After going through the questions and colors, the players had the chance to connect to each other further based on the mutual interest.

Interaction Concept Selection Criteria

The third interaction concept was chosen to develop further after discussing with other researchers. This concept was the only one that matched all the concept selection criteria provided in Figure23 [87]:

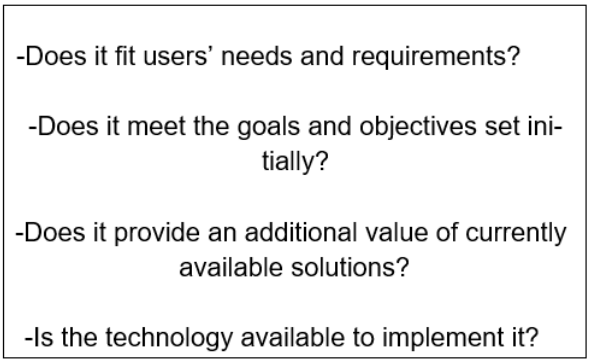

Figure23.*Concept Selection Criteria* [87]

-The interaction concept could achieve the goals and the objectives set for this master thesis, which was using social robots as acceptable facilitators of social connectedness for seminar attendees.
-It was possible to implement the game application based on users' feedback gathered during pre-study phase.
-The technology (Pepper) was available to use and implement the game on.
-The game was used to provide the users with a new form of interaction to enjoy and have fun and have positive experience with.

From this chapter of the thesis, we refer to the interaction concept as Color Game.

Color Game Design Rationale

The aim of Pepper in Color Game was to simply facilitate an ice-breaking game and create entertaining and pleasant experiences for the event attendees. The game was designed with a short and simple game-play to make it possible for busy event participants to play the game fast, and for the game to fulfill its purpose of connecting two people together through a fun ice-breaking interaction concept. The game was designed for two players to share simple fun facts about themselves and create an atmosphere where they had to finish the game in a new and fun way together. We were hoping that sharing fun facts about oneself in playful game could help even shy attendees to get to know few people in events. We added few gamification elements to the game to make the interaction experience fun and pleasant. Thus, we added the element of award and points in the game. The players received points based on their performance in the game. We implemented the concept of challenge and competition through a quiz where participants were questioned about each other's previously stated facts Table 2.

They received points if they answered the questions correct, and lost points if they answered wrong. Different sound effects were also used when a player pressed on the correct button, and wrong button. Also, Pepper announced the winner and played a short victory song while its eyes turned colorful. Similarly, Pepper's eyes changed based on the colors the players chose in the game selection part of the game, and also they changed in to different colors based on the question, and the color associated with that question. We have also implemented a countdown times in the statement completion chapter to add more excitement and fun to the game. The complete steps of the Color Game is provided in Appendix I.

Design Description of the Color Game

Pepper acts as the facilitator of social connectedness in the game and invites people to interact with the game application. Pepper gives the initial instruction of the game and ask the participants to input their names on the tablet (Figure 24).

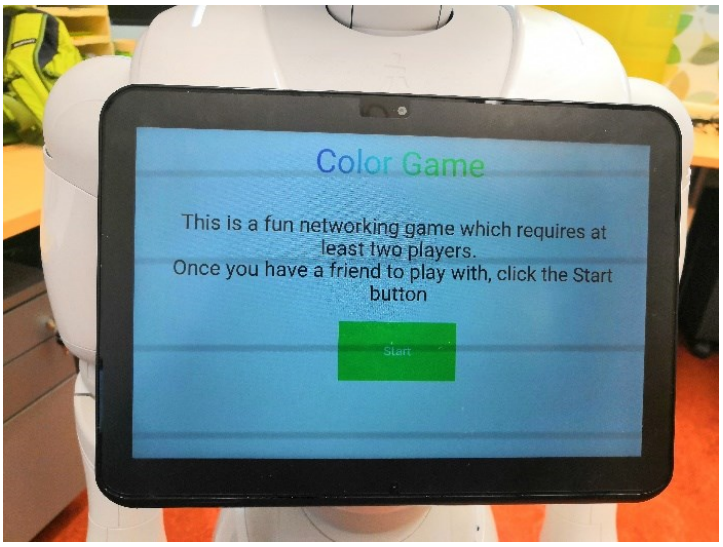

Figure 24. *The first screen of the color game*

Ten statements appear on the screen, and Pepper asks player one to complete the statements out loud (Figure 25). Each player has two minutes to talk about some basic fun facts statements about themselves, while the countdown timer is running and the person has to complete all the statements fast. In the meantime, the other player has to pay attention to the first player and listen to their answers. After two players complete the statements, the screen shows ten different colors and Pepper instructs the players that each needs to take five colors and drag them in the boxes (Figure 26). Each color is associated with one statement from the previous step that players had to answer (Figure 27). After players choose their colors, the next level starts Pepper by giving the instructions of the quiz. The quiz starts by questions appearing on the screen, and Pepper reading the questions out loud for the players, and players start answering the questions and getting points based on their answers. When the quiz is over, the winners' points appear on the screen and Pepper announces the winner (Figure 28).

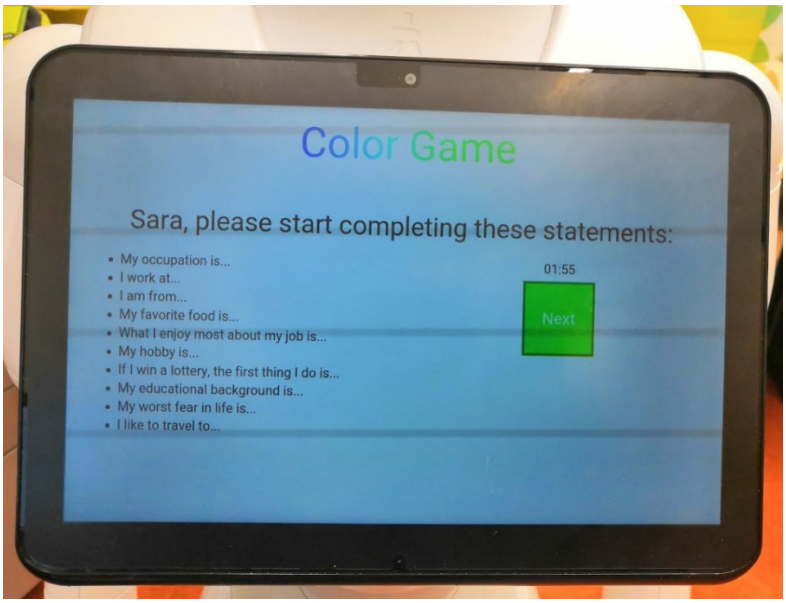

Figure 25. *The statements to be completed by the participants*

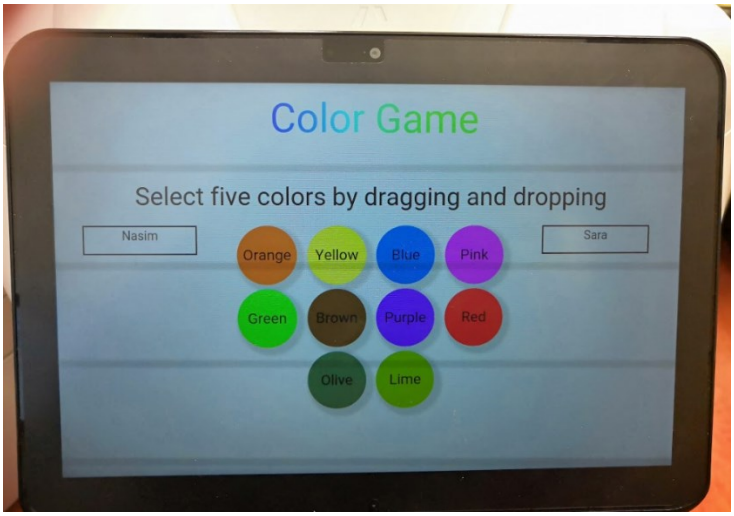

Figure 26. *Colors to choose by participants*

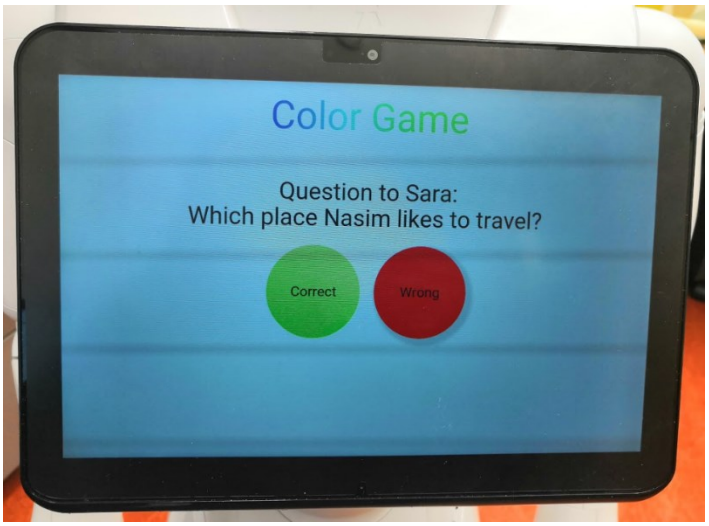

Figure 27. *Questions for players to answer*

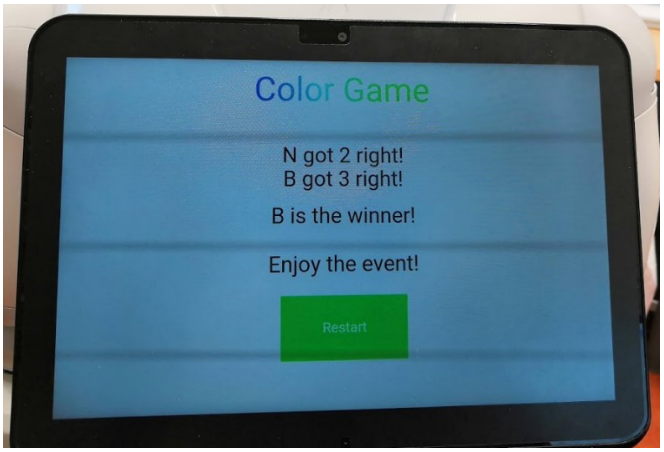

Figure 28. *Points earned by players are shown*

The list of statements used in the Color Game is provided in Table 2; they are very short and to point in order for the participants to understand them and answer them quickly. The idea for some of the topics of the statements are adapted from a previous study [26]. The statements are designed in a way to make the participants to share basic information about themselves in a fun way, which can maybe help them to connect to others who share the same similarities later.

Table 2. *List of personal statements*

1. My Occupation is….
2. I work at ….
3. I am from…
4. My favorite food is…
5. What I enjoy most from my job is…
6. My hobby is …
7. If I win a lottery, the first thing I do is …
8. My educational background is…
9. My worst fear in life is…
10. I like to travel to…

The colors and the questions associated with each color is showcased in Table 3. The questions are categorized based on the career path, current position and responsibilities, and free time activities people have in order to make the communication smooth and easy [88].

Table 3 *List of colors in Color Game*

Colors	**Questions**
Red	What was the other player's occupation?
Green	Which place the other player like to travel?
Blue	What is the other player's educational background?
White	What is the hobby of the other player?
Yellow	Where does the other player work?
Black	Where is the other player from?
Gray	What does the other player do first, if they win a lottery?
Pink	What was the favorite food of the other player?
Orange	What does the other player enjoy the most in his/her job?
Purple	What was the other player's worst fear in life?

5.2 Second Field Trial: Interaction Concept Evaluation and Findings

In this chapter, the procedure, methods and findings conducted to evaluate the Color Game is going to be explained in to more detail.

Color Game was tested as a field trial at an event organized at Tampere University of Technology, for the duration of four hours. The overall aim was to test the Color Game concept developed on Pepper with real users, and in the context of an event.

User testing procedure

The user testing lasted for two hours in the event held at KampusKlubi area of Tampere University of Technology. The event participants were able to interact with Pepper and the Color Game in the beginning of the event, and during breaks, and at the end of the event. The event participants were invited to play the games with another person whom they did not know, or they did not know some facts about the other player. The Color Game concept and the aim of the study was explained to the participants, and since Pepper was designed to do the facilitation, the instructions given by the author of this thesis was brief.

Data gathering

The evaluation methods used in Color Game user study were survey questionnaire, observations and semi-structured interviews. Before the interaction, the participants were handed the consent form and asked about their basic information (age group, occupation, and gender) and their level of interest in social robots based on a 7-point Likert scale with 1 (not interested at all) to 7 (totally interested) (Appendix G) to measure the participants' overall interest social robots. Additionally, the participants were asked about their prior experience in interacting with social robots, their previous seminar attendance, their interest in connecting with others at seminars, and their approach in connecting with others at seminars (Appendix G, questions 1 and 3-5).

After the game was completed, the participants were interviewed and were given another sets of questionnaire to complete. The questionnaire included another 7-point Likert scale asking the participants about the ice-breaking game how helpful it was in helping them to get to know others. In order to measure the experience of the participants from the ice-breaking game we used UEQs [79] with eight attributes (obstructive- supportive), (complicated-easy), (inefficient- efficient), (confusing – clear), (boring- exciting), (not interesting – interesting), (conventional- inventive), (usual-leading edge) with 7 scale

rating system to find out about the pragmatic and hedonic experiences (Figure 29) (Appendix J.2). Finally, we utilized RAS [77] similar to Pre-studies to find out about the users' attitudes towards Pepper. All the attributes of RAS were identical to the attributes used in pre-studies.

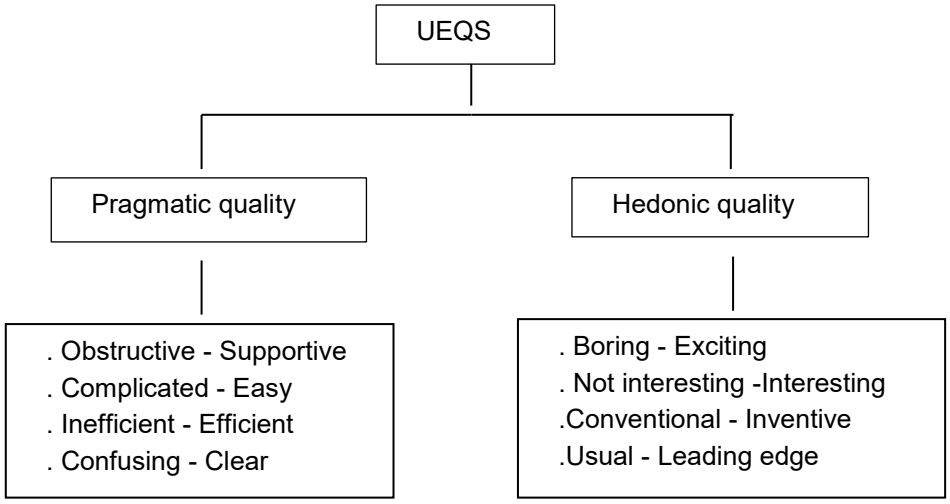

Figure 29. *UEQs items*

For qualitative data, the participants were observed throughout their whole interactions with Pepper, and the author of this thesis took notes on a free format observation notes. The observation were on people's curiosity in approaching Pepper and interacting with it, their feelings while interaction, the connections people made with each other after interacting with Pepper, and the honeypot effect around the robot. The other part of qualitative data was gathered from the semi-structured interview, which was utilized to find out how participants felt about interacting with the ice-breaking game, learn about their feedback on social robots as icebreakers at events, and find out how useful they thought the Color Game was in breaking the ice (Appendix H).

Data Analysis

The qualitative data was analyzed through content analysis method similar to the procedure explained in chapter 3 of the thesis. Through the content analysis we analyzed the observation and interview questions and found 18 themes overall (Appendix-L) , 4 themes for observation and 14 themes for interview questions. Basic statistics on Microsoft Excel was used to analyze the quantitative data.

Participants

In total, 12 participants attended Color Game user testing voluntarily. Most of the participants (9) were males. The participants were mostly (8) more than 41 years old, and they were mostly researchers. Most participants did not have prior experience in interaction with robots, and they were interested in social robots in general. More than half of the participants had attended seminar previously and were interested to meet others at events and connect with them. However, they mostly mentioned they only talk to people they know and familiar with.

Findings

This chapter reports the findings from the semi-structured interview, observations, and survey questionnaire conducted during Color Game testing.

Feeling about playing an ice-breaker game

The majority of the participants (9) mentioned they enjoyed and had fun with interacting with Color Game. They mentioned the game was fun, fast, and pleasant, and made them to wonder about the purpose of it. One participant mentioned "*I kept thinking what is coming next after the statements"* (M, 41+ years), the other participant stated "*I played because I got interested to see why everyone was introducing themselves in front of a robot*" (M, 41+ years). The remaining users believed the game was a nice way to interact with a robot and did not mention any specific details on how to make their experiences more positive.

Social robots connecting people at events

The majority of participants (10) believed social robots can be helpful in connecting people at events by matching the common interests among attendees, and making participants to perform collaborative tasks together. As one user stated "*I believe doing everything collaborative will make people to eventually talk, because collaboration and teamwork make people connect*" (F, 41+ years). Similarly, participants mentioned that sharing contact information with others can also make connections among event attendees. Playing games with the help of social robots was also mentioned by participants to make people connect at events. People were observed to be interested in Pepper by touching it while they were interacting with it, and asking questions about the purpose of the study and using Pepper in the study. In some occasions, people were interested to see more than just the game to understand the robot better, and find out about its capabilities. The rest of the participants seemed too busy to share their insights about social robots connecting people at events.

Color game as a helpful ice-breaker

Most participants (9) stated that they believed the game was helpful in breaking the ice, and made to know something fun about others. The rest of the participants (2) thought the game made them to share small fun facts about themselves with their colleagues and get to each other even better than before "*this game has potential, I wouldn't mind playing it with strangers, the statements are fun*" (M, 36-41 years). The participants were observed to share smiles and friendly jokes by going through the quiz questions. In one occasion while two colleagues were playing the games, one player acted surprise to find out that his colleague also likes to travel to the same destination, and he suggested they can go together during summer. People observing the players also smiled and enjoyed the game while others were playing and interacting with the robot. In one occasion one audience told one player to speak louder so he could hear him so he could know him better.

Role of social robots as ice-breakers at events

The participants mostly believed playing games with robots can make people to communicate and interact with each other better. As one person mentioned "*Playing games is a fun and entertaining way to get to know someone and you are less pressured to ask the person stupid questions, but you can get to know him easier by just playing the game"* (M, 26-30 years). Entertainment and guides were the next most suggested roles for the social robot to have to be an ice-breaker at evets. Informing about event schedule, and sharing contacts were the last two roles recommended for social robots as ice-breakers.

Curiosity and interest towards Pepper

It was observed that most people were interested to see what is Pepper doing at the event. In several occasions people approached the author of this thesis and asked about the purpose of Pepper in the event. People were mostly curious about Pepper's capabilities, and they touched and took photos with it while it was interacting with people. *The honeypot effect was evident during the interaction with Pepper. People gathered around and got interested when they saw others interacting with the robot.* People were interested to find out what the game was about so they stopped and watched the game, and joke about it with friends, or just smiled and watched the whole interaction from distance.

Figure 30. *Participants interacting with Color game*

User experiences from interaction with color game

Mean Evaluation of UEQs attributes showed that most participants had positive hedonic and pragmatic experiences from interacting with the Color Game. UEQs consists of scale of -3 (extremely bad) and +3 (extremely good) for measuring user experience of products. The analysis of data showed that both pragmatic and hedonic attributes are located on the positive side of the scale, which means the user experience of attendees were positive from the game and the event in general (Table 4 and Figure 31). The pragmatic attributes were located higher than the hedonic attributes, however the difference is very small and un-noticeable. Figure 31 displays the eight attributes of UEQs and their mean values; this figure can make it easier to see the difference between the attributes and their mean values.

Table 4. *UEQs values*

Mean	Std. Dev.	Negative	Positive	Scale	
1,2	1,3	obstructive	supportive	Pragmatic Quality	
2,1	0,8	complicated	easy	Pragmatic Quality	
1,4	1,3	inefficient	efficient	Pragmatic Quality	
1,5	1,4	confusing	clear	Pragmatic Quality	
2,0	1,3	boring	exciting	Hedonic Quality	
0,4	1,1	not interesting	interesting	Hedonic Quality	
1,4	1,6	conventional	inventive	Hedonic Quality	
1,3	1,6	usual	leading edge	Hedonic Quality	

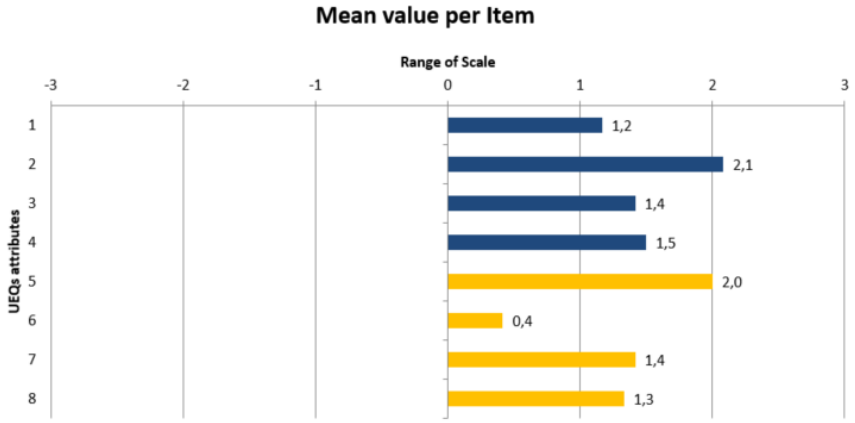

Figure 31. *The result of positive hedonic and pragmatic experience*

UEQs has also a benchmark that is created from a large sample of UEQ evaluation results from science and industry projects. Figure 32 and Table 5 show the results of our findings against the benchmark set by Schlepp [89]. Table 5 shows the average mean for hedonic and pragmatic attributes. Figure 32 displays the average and the overall mean of hedonic and pragmatic qualities. Based on Figure 3 it is evident that all scales are located above the average towards excellent, this can indicate that participants had quite positive experience and impression from Color Game.

Table 5. *Explanation of the results of the color game against UEQ benchmark set*

Scale	Mean	Comparisson to benchmark	Interpretation
Pragmatic Quality	1,5	Good	10% of results better, 75% of results worse
Hedonic Quality	1,3	Above Average	25% of results better, 50% of results worse
Overall	1,6	Good	10% of results better, 75% of results worse

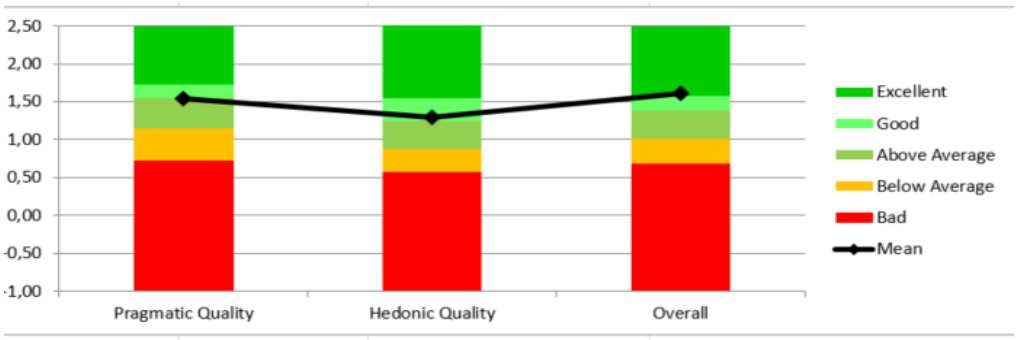

Figure 32. *Results of the color game against benchmark set*

Attitudes towards Pepper

In terms of RAS, the results indicate that participants (n=12) had positive attitude towards Pepper in general (Figure 33). The attitude of the participants were mostly positive in attributes of friendliness, complication, safety, and helpfulness of Pepper. The attributes of trustworthiness, and advancement have the lowest mean on the scale.

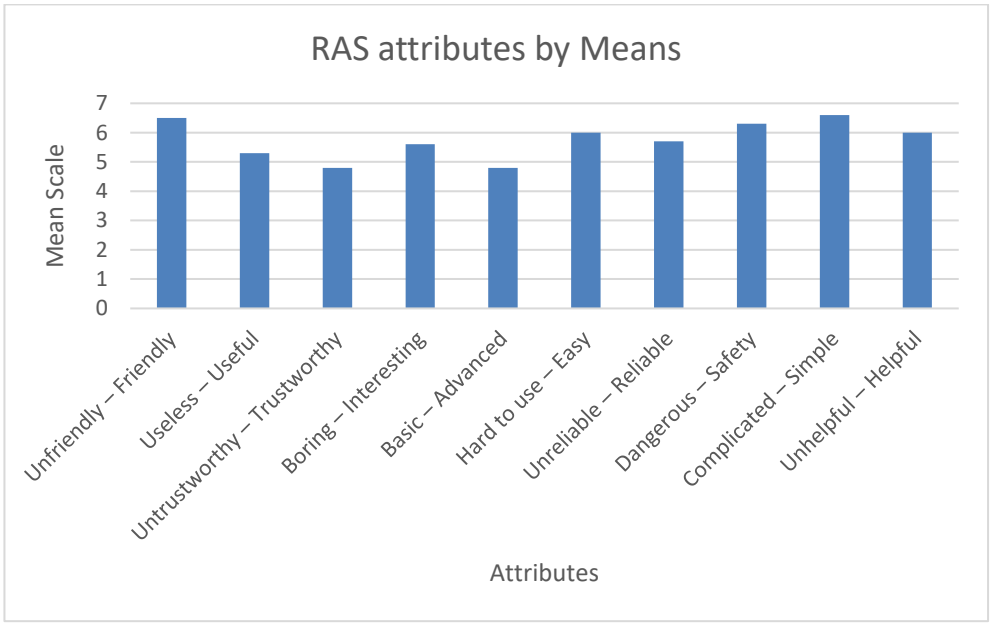

Figure 33. *RAS attributes by means*

By comparing the robot attitude survey of the first field trial (n=31) and the second field trial (n=12) we identified that people had positive attitude towards social robot Pepper (**Error! Reference source not found.**). The attributes of RAS in both field trials were close to each other, indicating that people were mostly enjoying their experience in meeting Pepper and interacting with its applications. The small difference between reliability

and simplicity attributes of RAS can interpret we were able to succeed in making Pepper's application simpler and more reliable for second field trial.

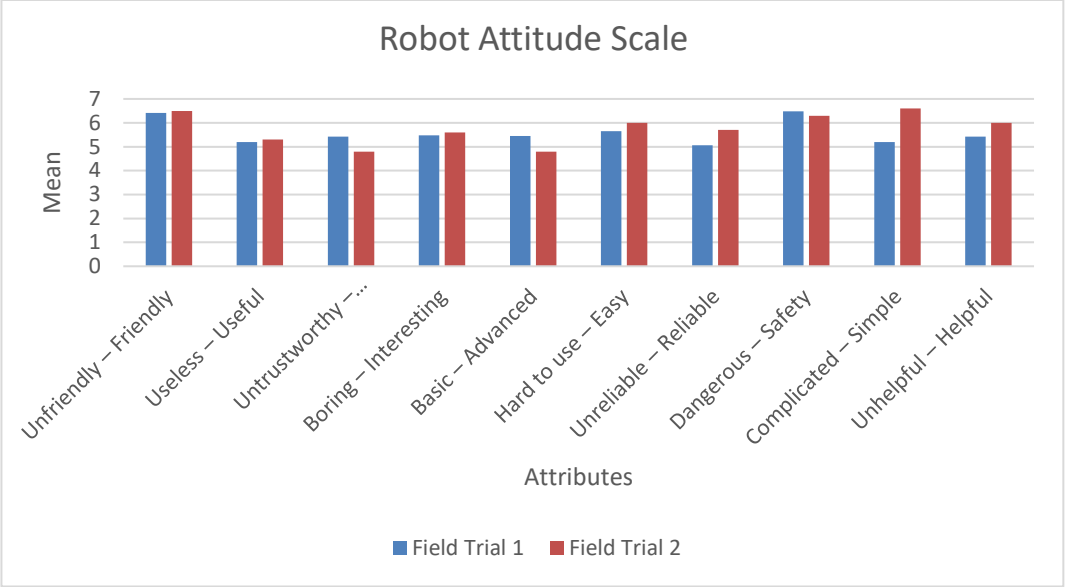

Figure 34 *Comparison of robot attitude survey in two field trials*

5.3 Summary

From the analysis of the Color Game concept we found out *Pepper was interesting* to the majority of the participants, and people were attracted to interact with it by touching it and speaking to it, or playing the color game with it. Users were curious about social robots, and they became interested once they saw others interacting with the robot. *The overall attitude of participants was positive* about Pepper and they found it to be mostly simple, helpful, safe, and friendly. In terms of their experience, *the majority of participants had positive user experience in interacting with the color game.* They found the game to be exciting, easy to play and they believed the game served its purpose and *could connect people together*. The game was believed to be *creative and novel to play* through facilitation of Pepper. The participants *enjoyed their interaction and shared positive feelings* about their communication with Pepper and the game. The event attendees believed *social robots can be ice-breakers and connect people together through collaborative tasks*, such as games, and competition or by matching people with mutual interest together.

6. DESIGN IMPLICATIONS OF SOCIAL ROBOTS AS ACCEPTABLE FACILITATORS OF SOCIAL CONNECTEDNESS

During our field trials and literature review research, we discovered several useful elements, which could be used as design implications of social robots as acceptable facilitators of social connectedness. Thus, we have put together a list of twelve design implications for this purpose. This is not a complete list, and future work can elaborate it further.

Design implications found in field trials

-*Design simplistic robotic applications*: during the Color Game user study, one factor that we got many feedback was the simplicity of the game concept we implemented. People enjoyed interacting with simple concept, and believed easy to use applications will keep the person interacting with the robot interested to complete their task on the robot. If systems become so demanding and confusing to the user, he or she will lose interest and will stop interacting with the robot. Moreover, if the interaction is too long, the user might also lose interest and become bored.

-*Include entertaining features in robotic applications*: based on our findings during pre-studies and Color Game user study, we found out one way for people to accept social robots and interact with them is through entertainment. Robots as entertainers, or robots with entertaining applications will attract more attention, and people feel less threatened to approach them and interact with them. Thus, it is advisable to implement entertainment factors in designing social robots, and social robots platforms.

-*Implement ice-breaker features in robotic applications*: social robots can break the ice through their applications by providing topics of conversation, games, or matching people with common interests together. In the literate review chapter, we covered various solutions, which offer users with means to become comfortable to socialize with strangers at events. Most of these means revolve around introducing topics of conversation, games, and match people based on their mutual interests.

-*Make the robot's application multi-lingual*: it is good to implement social robots with language used mostly by the user groups, or make multi-linguistic feature available on applications. During our user studies, we were asked in some occasions if the robot could interact in Finnish, French or Spanish. Some users became disappointed to find out the robot's application were only implemented in English language.

-*Implement robotic applications with collaborative features*: During our study we found that people were more comfortable to interact with the robot in groups. We observed people to dance in groups with the social robot, take selfies in groups, interact with games in groups, and even play in groups. Thus, it is advisable for social robots to have features that make people to interact with them collaboratively. This way even shy users can join the others and enjoy the interaction.

Design implications found during research studies

-*Design social robots with natural human-like features*: social robots need to communicate with human beings, it should understand and should be able to relate to humans in personal way. Therefore, it is important to create robots that appear and behave in human-like manner. Implementing human-like signals and cues can help robots to act more human-like. These signals are available in human's face, and gestures. Designers of social robots can implement features of human faces in developing robots face, for instance eye movements, eye gaze, and some minor level of emotions and facial expressions [90]. Implementing variable gestures can also add value to the perception of social robots. Also, the behavior of the robot needs to be believable and match the expectations of human beings [49].

-*Implement social robots with social capabilities:* social robots need to be able to communicate with humans and produce expressiveness through speech, emotional expressions, and gestures. The anthropomorphism abilities will help in people's perception of social robots' capabilities, which lead to acceptance of social robots. However, implementing too much an anthropomorphic features will result in reverse effect and cause uncanny valley. It is best for designers to create social robots features artificial, but interesting and appealing for users to interact with. [91]

-*Develop social robots with expressive emotions:* implementing emotional expressions in robotic design will help the interaction to be familiar to users. This will create a positive emotional communication between the user and the robot, which lead to social facilitation interaction [91]. People are believed to find the robots that show emotions to be more

likeable, trustworthy and caring. Implementing emotions in HRI can help to decrease stress, and frustration in users, and increase in user's satisfaction, and comfort in engaging with the robot [92].

-*Design social and cultural influential factors:* social and cultural influences are important factors in designing social robotics. In some countries people are more cautious of their approach and communication with new type of technology. In implementing humor and fun factors it is important to know not all cultures are open to humor and fun in the same way. A fun element in an application might not seem fun and joyful to another culture. Some cultures are more conservative in their style of fun and humor.

-*Implement social robot's moderate speaking style during interaction*: Aim for moderate pace in interaction and accurate data between users and the social robot. It is important for the robot to provide the user with quick answer to their requirements otherwise, the person interacting with it will lose interest and will move on. Similarly, if the information provided by the social robots is not accurate users will lose interest in the robot and will have negative experience in their interaction [93]. Therefore it is helpful to maintain a reasonable pace of info delivery for the user. Similarly, the robot needs to speak to people in a polite and elegant manner [92].

-*Apply human-oriented perception during interaction*: social robots must have the ability to perceive and accurately interpret humans' behavior and activity [49]. This way the robot can understand humans better and expect their behavior in the interaction.

-*Implement fun and humor elements in robotics design:* implementing fun and humor elements in designing applications for social robots can lead to higher acceptance of these robots. Fun and humor can increase the likeability in users, since this can lead people to see robots to be more human-like. In previous study [92] humorous and fun robots received more positive scores than non-humorous and fun robots. Humor and fun are studied to be factors that engage users to keep social conversations with robots.

7. DISCUSSION AND CONCLUSION

This chapter covers the summary of the key findings from the user studies done, the answers to the research questions, limitations of the study, and conclusion.

7.1 Summary of Findings

By conducting pre-studies with 43 participants in the contexts of a university and a seminar, we identified the viewpoint of users about social robots. Additionally, we found out what the users' thoughts were on the topic of robots as acceptable facilitators of social connectedness. During user studies, the participants were interviewed, observed, and filled out survey questionnaires adapted from previous studies. After data analysis, the findings suggest that *social robots can be acceptable facilitators of connectedness for event attendees by entertaining the audience*. *By providing entertaining activities for users, social robots can be helpful in breaking the ice* and making it easier for the event attendees to get familiar with new people at the event. Entertainment in the form of games was suggested during the user testing trials. *Playing games using the robot can be attractive to users* in addition to *motivating users to interact* with the robot and enjoy their communication. These findings respond to research question 1. **How can social robots act as acceptable facilitators of social connectedness for seminar attendees?**

By conducting the Color Game user testing, with 12 participants during a university event, we were able to test the Color Game concept developed based on the feedback received in previous user studies. During this trial, we were able to uncover how social robots can create pleasurable and positive experiences for event attendees. The findings suggest that *the attitude of users towards social robots were positive,* and the *users had positive user experiences* in their interaction with the game and the robot. Additionally, the event was believed to be less formal than usual events because the *social robot was able to facilitate social connections* and the robot was mentioned to have a potential to *break the ice* by few users. The positive attitude, and positive user experience can ultimately lead to user acceptance of technology and in this case, acceptance of social robots as ice-breakers at events. We identified that factors such as *fun*, *joy*, *ease of use*, *novel* and *creative robotic concepts* can lead to *creating pleasurable and positive experiences for event attendees.* These findings respond to research question 2. **How can**

social robots create pleasurable and positive user experience for seminar attendees?

During our field trials and research we found several design implications to consider when designing for social robots as acceptable facilitators of connectedness. These elements can be used in order to design and implement more useful and appropriate applications in social robotics. The design implications include 12 items across two categories of field study discovered elements, and research discovered elements. Table 6 displays 8 most important of these elements. To read the complete list refer to chapter 6 of this thesis. This list can respond to research question 3. **What are the design implications for robots as acceptable facilitators of social connectedness at events?**

Table 6. *Design Implications*

Design Implications	Summary	Source
Design simplistic robotic applications	Easy to use applications will keep the person interacting with the robot interested	User Field trials
Include entertaining features in robotic applications	Robots with entertaining applications will attract more attention, and people feel less threatened to approach them	User Field trials
Implement ice-breaker features in robotic applications	Social robots can break the ice through their applications by providing topics of conversation, games, or matching people with common interests together	User Field trials
Implement robotic applications with collaborative features	People were more comfortable to interact with the robot in groups	User Field trials
Develop social robots with expressive emotions	Implementing emotional expressions in robotic design will help the interaction to be familiar to users	Related research
Design social and cultural influential factors	In implementing humor and fun factors it is important to know not all cultures are open to humor and fun in the same way	Related research
Implement social robots moderate speaking style during interaction	It is important for the robot to provide the user with quick answer otherwise, the person interacting with it will lose interest	Related research
Apply human-oriented perception during interaction	Social robots must have the ability to perceive and interpret humans' behavior	Related research

7.2 Discussion

As of the time of writing this thesis, the topic of social robots as facilitators of social connectedness at events has not been studied in depth before. Our topic of study is novel with only few previous research conducted that study social robots creating connections among strangers, and young adults [15,14]. Currently, there is only one study of connecting people using robots, where the researchers used a virtual assistant robot at a conference [16]. Our approach in this research was to apply HCD and constructive design research approaches to develop robotic concepts based on users' needs and requirements. We conducted field trials with authentic users interacting with a social robot using a variety of interactive concept applications. We implemented interactive applications that helped us to study how social robots can support connectedness among event attendees in addition to creating positive user experience. Additionally, we were able to construct a list of design implications, which were developed based on our own findings and previous research.

Our findings from one pilot study and two field trials, suggest that social robots can be capable of supporting social connectedness at events in addition to being used as ice-breakers. Similar to previous studies, we also learned that some people found socializing with strangers during events uncomfortable and challenging [2,25]. To make the socializing process less challenging and more positive, we implemented an ice-breaker game to engage people in social interactions. Our findings suggest that playing a collaborative ice-breaking game even in a form of a two-player game can provide a source of interaction and conversation among strangers. Similar to the study done by Jarusriboonchai et al. [26], our Color Game concept was able to break the ice among people and was able to create a friendly atmosphere for users to socialize and interact. Similar to previous studies [35], our findings identified that elements of fun and joy made the event experience more positive for the users, in addition to providing a more relaxed and comfortable environment. Similar to previous study [36] and based on our findings, we believe that applying few gamification elements in the Color Game made the game more enjoyable and fun to the users. Applying few game rules such as elements of reward and challenge made the user to be more engaged in the game and the overall user experience to be positive.

We found out that Pepper was accepted by event attendees and fulfilled their expectations as they liked its robotic features and they became interested to approach and interact with it with joy and pleasure. We witnessed this phenomena during both field trials, where Pepper's human-like features and behavior including its gestures, eye con-

tact, and phrases were interesting to many attendees, and made them curious to approach and interact with it. Our results are in line with previous research studies [15, 70, 48, 73], indicating that people prefer to interact with robots, which appear to be more human-like, as this will lead them to accept and adapt to robots better, and have positive experiences.

We discovered that Pepper was able to create pleasurable and positive experiences for participants during events. By adapting previous methods of measuring user experience, we were able to measure the hedonic and pragmatic qualities during our field trials. Similar to previous research [48,64], we found that pragmatic qualities such as usefulness of the robot lead to satisfaction of the users. Additionally, the simplicity of the robot's interaction and the interactive applications, led to pleasant experiences during communication, and a positive user experience. As proposed by a previous study [67], we found that robot's attractive features including its appearance, identity, and gestures to be affective on people's hedonic experiences. We conclude that these features were the driving factors leading people to approach and interact with Pepper during their first encounter. Unlike previous study [15] that reports usefulness and ease of use factors are not as sufficient as hedonic factors such as enjoyment and sociability, we found that both hedonic and pragmatic qualities can be equally important in HRI. Most participants in our user study had positive hedonic and pragmatic experiences from interacting with the Color Game. The pragmatic and hedonic attributes were located both on the positive side of the scale, meaning the user experience of attendees were positive from the game and the event in general.

Our findings suggest that simplicity of the robotic application was important in keeping the person interested in interacting with the robot. We believe implementing appropriate hedonic and pragmatic qualities in social robotic applications will keep people interested to interact with robots for some time, and the novelty factor fades away in a slower pace. However, we did not find any data suggesting for how long people will stay interested in interacting with social robots at events. One possible way can be to design new and entertaining robotic concepts occasionally so people do not get bored interacting with the same concepts overtime. However, ideation, iteration, and implementation of new robotic concepts require multiple resources, which can become costly for event organizers.

Similar to previous research [43], our study also suggest that the physical embodiment of a robot including its appearance and social capabilities play major roles in human-robot interaction. We observed that people were interested in Pepper's human-like features. Based on our findings we found that people felt comfortable interacting with Pep-

per because they were interested to see and communicate with a robot that was resembling humans. We believe in order for robots to act as successful social facilitators, they need to have efficient social interaction with humans. Therefore, as it is studied by previous studies [50,48], it is important to design robots' physical embodiment in ways that make them capable to communicate verbally and nonverbally in human-like ways. Applying appropriate physical embodiment can make people curious and interested in robots, which can lead to continuous human-robot interaction. Our study suggest that one factor that might led for the robot to be a successful social facilitator was the fact that both *the concepts and the physical embodiment of the robot was accepted by users*.

As of the time of writing this thesis, there are no clear design implications, which can help social robot developers to implement concepts for robots' facilitation of social connectedness at events. Thus, we have put together a list of twelve design implications for this purpose. Although our provided list includes some parts of previous research, the elements were not formerly identified in a single list. Our design implications can contribute to the field of HRI and help improve social robotic applications, aiming to help people to connect to each other and enhance socialization at events. Using these design implications can help robotic designers save time, money, and resources, and avoid potential misfortunes in the future.

7.3 Limitations

Throughout this thesis process we have faced some challenges explained in the following paragraphs.

Implementation and development - during the thesis it was challenging to develop interaction concepts, which were more accurate and relevant to the design ideas. The robotic application development was completely depended on a programmer who was not working solely on this topic, thus limited time and resources were allocated for implementation of the concepts used in this thesis. Having more resources could have helped in testing different conceptual scenarios. If the author of this thesis had knowledge of programming and robotic development, there could be more time spent on perfecting the applications.

Iteration - the first concept followed by the second concept, and there was not enough time to iterate the developed applications. Iteration requires a lot of time and re-designing, which was out of the time scope of this thesis. Based on HCD approach it is required to re-design and re-test the concept ideas in order to come up with more accurate findings [75]. During the first concept (Welcoming application) we faced some issues in providing the users with the accurate data needed to get informed about the seminar.

Also, during the first concept, we faced some challenges in development. The prototype was not working properly, and the developer was not available to make the necessary changes. Therefore, we had to assign a new and busy developer in a short span of time to develop the concepts further, and there was not enough time to make any iterations before the first field trial.

Novelty factor – When people are first introduced to a novel product they are interested to interact with the product, but after the novelty fades away they lose interest [94]. People become bored very fast and they expect the robot to behave differently after a while. In another words the novelty factor fades off and people become tired of repetitious behaviors. Therefore, if the social robot has the entertainer and ice-breaker role the developers need to keep updating the interaction with new elements and introduce the new features so people stay interested in the robots. All the user studies conducted in this thesis were performed one time only, and we did not have enough resources to explore the long-term usage of the concepts further.

Events and sample – Lack of events to test out the concepts made it challenging to be convinced about the accuracy of the findings. It was better if we could test the concepts with more people in more seminar contexts to find out about their thoughts and feedback on the topic. Moreover, the findings of our field trials may not be generalizable, as the sample size was still relatively small and the trials were all done at the same university.

Robotic limitations – Pepper has some technical limitations that made it hard to interact during field trials. For example, the speech recognition becomes challenging when the surrounding environment is noisy and crowded. During the first field trial, it got so noisy and crowded, which was impossible to interact with Pepper at all. Some people lost interest in interacting with Pepper, when they saw Pepper incapable of recognizing their commands. The pace of Pepper's speech was fast for some people, and made it impossible for few people to understand its instructions properly. Some people asked the author of this thesis to slow down the speech pace. The brightness of the tablet is set to low, and it was hard for some people to see the text properly.

7.4 Conclusion

In conclusion, by adapting HCD and constructive design research approaches, we implemented concepts after getting feedback from the target users. We based all the concept design ideas on the feedback and opinion of the seminar attendees who participated in pre-studies and we designed an entertaining Color Game concept to evaluate the capabilities of social robots as facilitators of social connectedness at events.

We were able to find out that social robots can make the process of socializing at events more comfortable and pleasurable by providing fun and collaborative ice-breaker activities. We found that pleasant experiences will lead to acceptance of social robots that ultimately lead to people willing to interact with these robots and welcome them in to their lives in the near future. Furthermore, our results suggested that social robots can be used as ice-breakers among strangers by means of collaborative tasks such as a two-player game.

By introducing social robots in humans' lives, these robots can become ubiquitous in the society, which will increase the familiarity of people towards them therefore more people use them in their lives. Thus, it is important to design robots in ways that make people stay attentive in interacting with them. At the same time, it is crucial to update the robotic features so users do not become bored and stop communicating with robots. Developers should pay attention to two major UX qualities that derives people to stay motivated in interacting with robots. These are hedonic and pragmatic qualities. The usefulness and simplicity of the robot (pragmatic) should be considered in developing for HRI. If people find a robot useful in its role and simple to work with, they will be willing to welcome it to their lives. Moreover, creating factors of joy and pleasant appearances in HRI can make it easier for people to accept social robots and make the interaction smoother.

Finally, we created a list of design implications for social robots as acceptable facilitators of social connectedness at events. The list included twelve main points, which may be helpful for future field of HRI. Some examples of the design implications include design simplistic robotic applications, include entertaining features in robotic applications, implement robotic application with collaborative features, Design social robots with natural human-like features and Implement social robots with social capabilities.

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9. APPENDICES

Appendix A – All User Studies Consent Form

I agree to participate in the user study conducted by Tampere University of Technology as part of the research process of Nasim Beheshtian for her master thesis.

I consent and give permission for taking video/audio recordings by Tampere University of Technology. I understand that my personal information and identity will not be shared with anyone.

I understand that data gathered during this study will be used for analysis at a later stage and that my words may be quoted in published papers.

Participant's name ----------
Participant's signature ----------

Appendix B – All User Studies Background Information Form

Thank you for taking time to answer this survey. The following information is used for statistical data analysis and your personal data will not be shared with anyone.

Age (<25) (26-30) (31-35) (36-41) (+41)

Gender (M/F/Do not want to say)

Occupation (_____)

Appendix C – Pilots Study Questionnaire Form

1.Have you ever interacted with a social robot? (Yes, No)

2. Are you interested in social robots in general?

Not interested at all o o o o o o o Very Interested

3.Have you ever attended a seminar or a conference?
(Many times, few times, Never)

4.Do you like to connect/network with other people at events or seminars?
(Yes, No, Maybe)

5.How do you get to socialize with other attendees at a seminar or a conference?
(I approach them, They approach me, I only talk to those I already know, I do not socialize)

Appendix D – Pilots Study Interview Questions

1. How do you feel about social robot Pepper?
2. What did you think about Pepper's entertainment (dance, hug, etc.)?
3. Have you ever attended a seminar or a conference? How do you get to know other people at seminars?
4. How do you think a social robot can be helpful in connecting people at events?
5. How do you think a social robot can act as an icebreaker at events?

Appendix E – First Field trial Survey Questionnaire

1.Have you ever interacted with a social robot? (Yes, No)

2. Are you interested in social robots in general?

Not interested at all o o o o o o o Very Interested

3.Have you ever attended a seminar or a conference?
(Many times, few times, Never)

4.Do you like to connect/network with other people at events or seminars?
(Yes, No, Maybe)

5.How do you get to socialize with other attendees at a seminar or a conference?
(I approach them, They approach me, I only talk to those I already know, I do not socialize)

6. I think the robot is

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
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

Appendix F – First Field trial Interview Questions

1. Is this your first-time meeting Pepper or similar kind of social robot? If not, where have you met those before?
2. How did you feel about Pepper welcoming you to the seminar? What did you like and dislike?
3. What did you think about Pepper's entertainments (dance, hug, etc.)?
4. How do you get to know other people at a seminar or a conference?
5. How would you think a social robot can be helpful in connecting people at events?
6. How would you think a social robot can act as an ice breaker at events?

Appendix G – Color Game User Study Questionnaire

1.Have you ever interacted with a social robot? (Yes, No)

2.Are you interested in social robots in general?

Not interested at all o o o o o o o Very Interested

3. Have you ever attended a seminar or a conference? (Many times, few times, Never)

4.Do you like to connect/network with other people at events or seminars? (Yes, No, Maybe)

5.How do you get to socialize with other attendees at a seminar or a conference? (I approach them, They approach me, I only talk to those I already know, I do not socialize)

6.Ice-breaking games can make it easier for me to get to know others
Strongly agree o o o o o o o Strongly disagree

7.The icebreaking game is… **(Measuring UEQs)**

obstructive	o o o o o o o	supportive
complicated	o o o o o o o	easy
inefficient	o o o o o o o	efficient
confusing	o o o o o o o	clear
boring	o o o o o o o	exiting
not interesting	o o o o o o o	interesting
conventional	o o o o o o o	inventive
usual	o o o o o o o	leading edge

UEQs attributes

8. I think the robot is…

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
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

RAS attributes

Appendix H – Color Game User Study Interview Questions

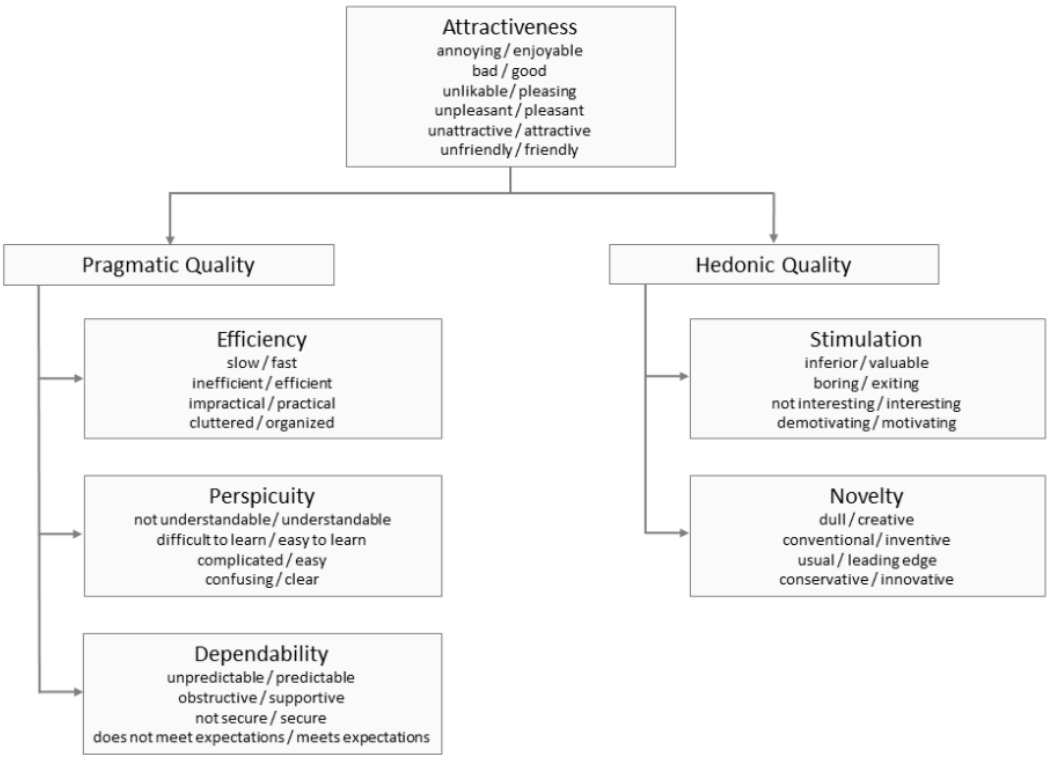
1. How do you feel about playing an icebreaker game with a help of a social robot?
2. How do you think social robots can be helpful in connecting people at events?
3. Was the game helpful in breaking the ice? How?
4. How do you think a social robot can act as an icebreaker at events?

Appendix I – Steps in Playing the Color Game

1. Pepper invites people to approach and play the game
2. Pepper tells the participants that the game is a 2 player game, so if there is only person he or she should ask another person to join them
3. Pepper provides the instructions of the game to the participants
4. Pepper starts the game by dancing for a short amount of time to attract more people in the game and make it more fun for players
5. The game begins
6. Pepper asks each player to identify themselves by writing their names in the boxes appearing on the tablet mounted on Pepper's chest
7. Pepper asks the players to face each other
8. Game starts, ten statements appear on the screen and the first player has 2 minutes to complete them. Pepper asks the first participant to start completing each statement shown on the screen one by one.
9. The timer is showing on top of the screen and when time is up Pepper will rise its hand to stop the player from talking.
10. The same procedure happens for the second player.
11. In the next step Pepper will instruct the new phase of the game to the players.
12. Various colors appear on the screen, which are associated with questions about the previous statements. Each player has to choose 5 colors of their choice. It is first player's turn to start the game. The first player has to answer questions, which are about the second player, and the second player presses on the right or wrong button based on the answer of the first player. This phase is for the players to listen to each other and get to know how much they learned from each other in the previous statements.
13. The winner is the player who answers the most correct answers in the shortest amount of time.
14. Pepper shows how many correct answers each player answered and announces the winner and plays a music at the end.
15. Pepper will announce the winner and will ask the players if they want to connect to and share their contact information

Appendix J – User Experience Questionnaires

Appendix J.1



User Experience Questionnaire (UEQ) [79]

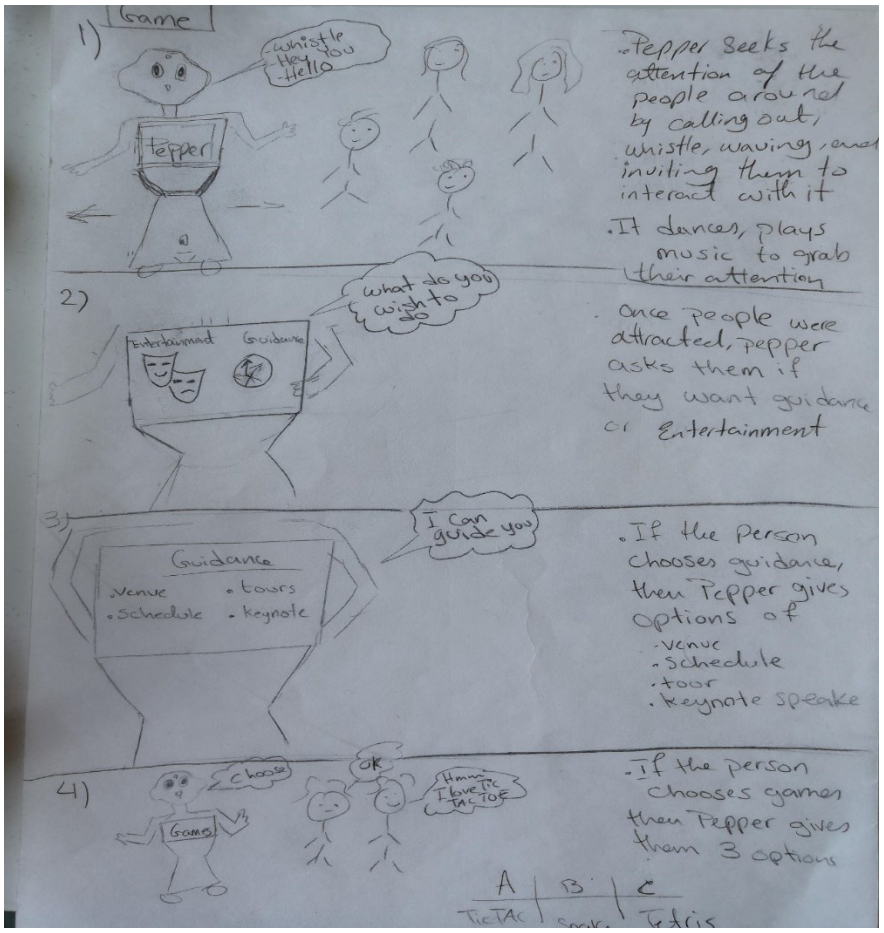
Appendix J.2

obstructive	o o o o o o o	supportive
complicated	o o o o o o o	easy
inefficient	o o o o o o o	efficient
confusing	o o o o o o o	clear
boring	o o o o o o o	exiting
not interesting	o o o o o o o	interesting
conventional	o o o o o o o	inventive
usual	o o o o o o o	leading edge

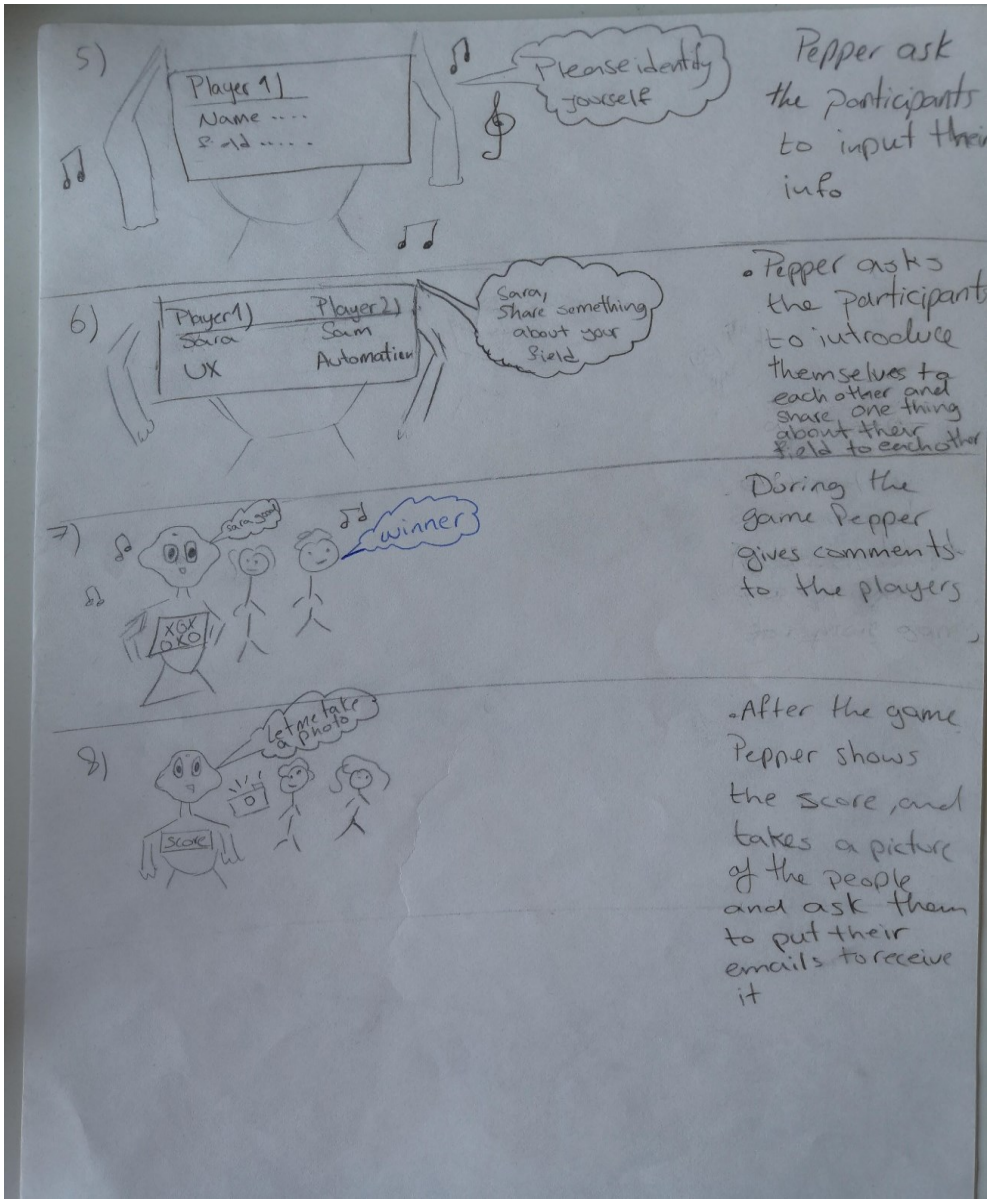
User Experience Questionnaire Short Version (UEQs) [79]

Appendix K – Hand-drawn Sketch of the Interaction Concept Ideas

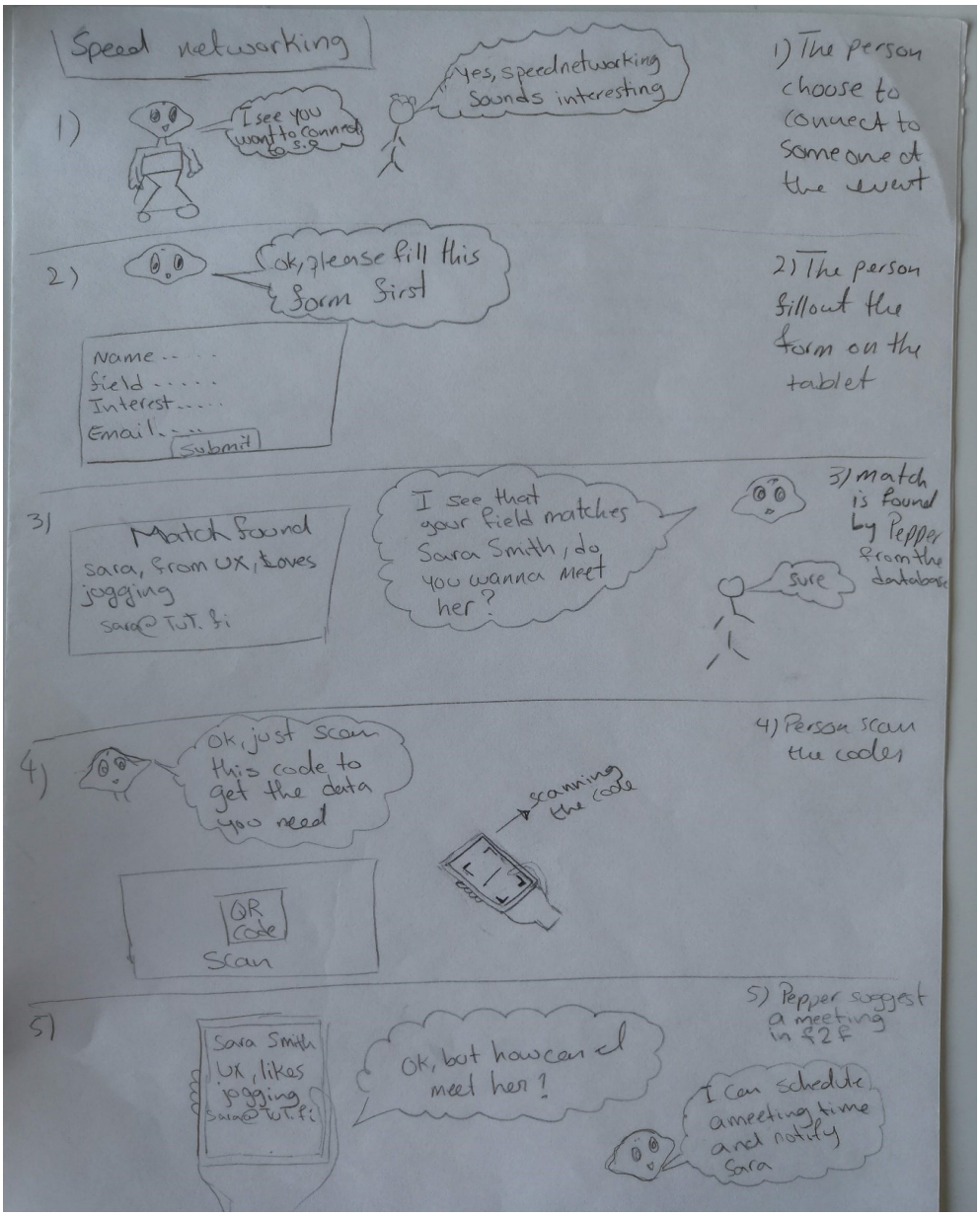
Appendix K.1 Games Concept



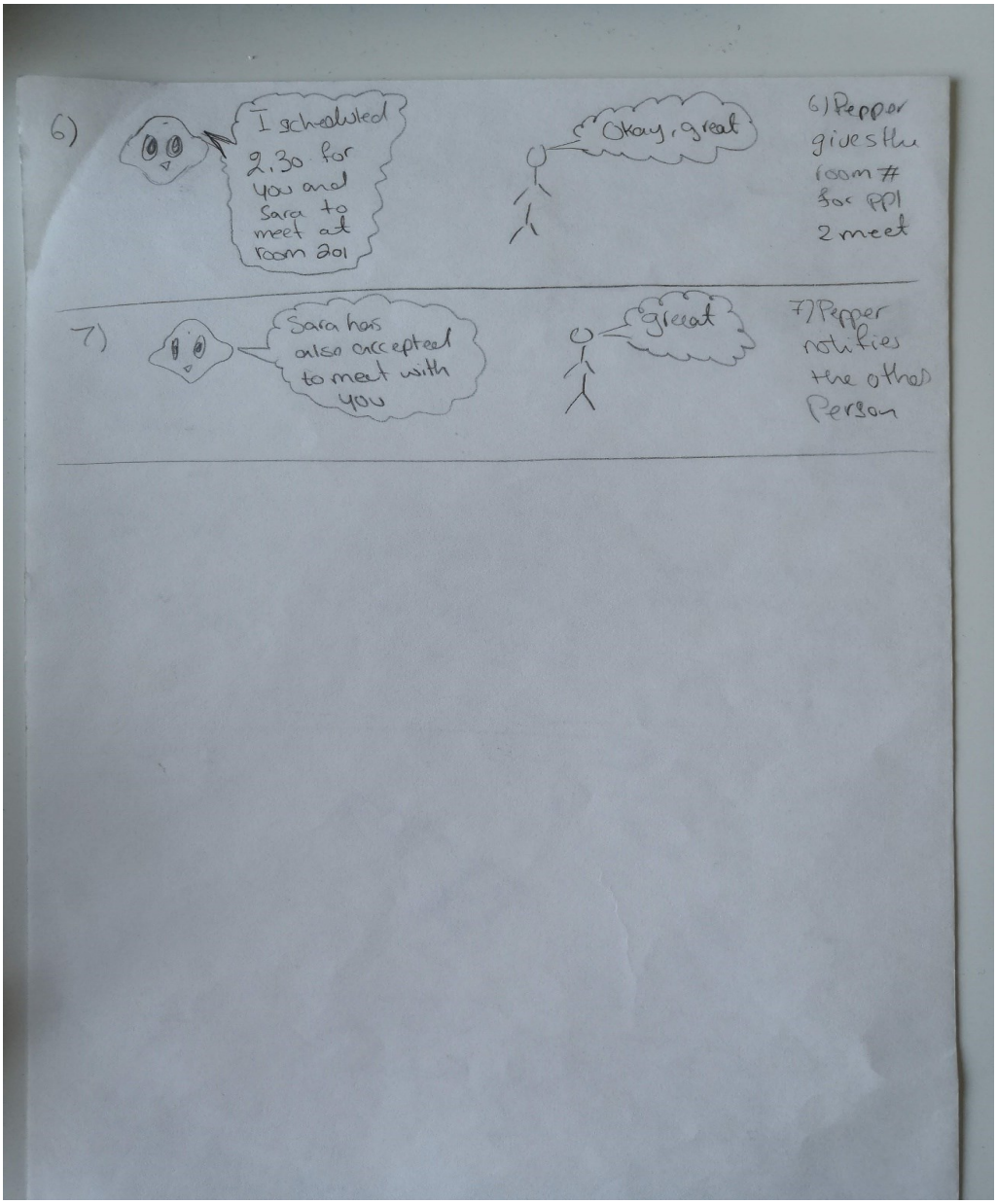
1


5)
Player 1
Name ....
Field .....
Please identify yourself
Pepper ask the participants to input their info
6)
Player1)
Sara
UX
Player2)
Sam
Automation
Sara, Share something about your field
• Pepper asks the participant to introduce themselves to each other and share one thing about their field to each other
7)
winner
During the game Pepper gives comments to the players
8)
Let me take a photo
Score
• After the game Pepper shows the score, and takes a picture of the people and ask them to put their emails to receive it

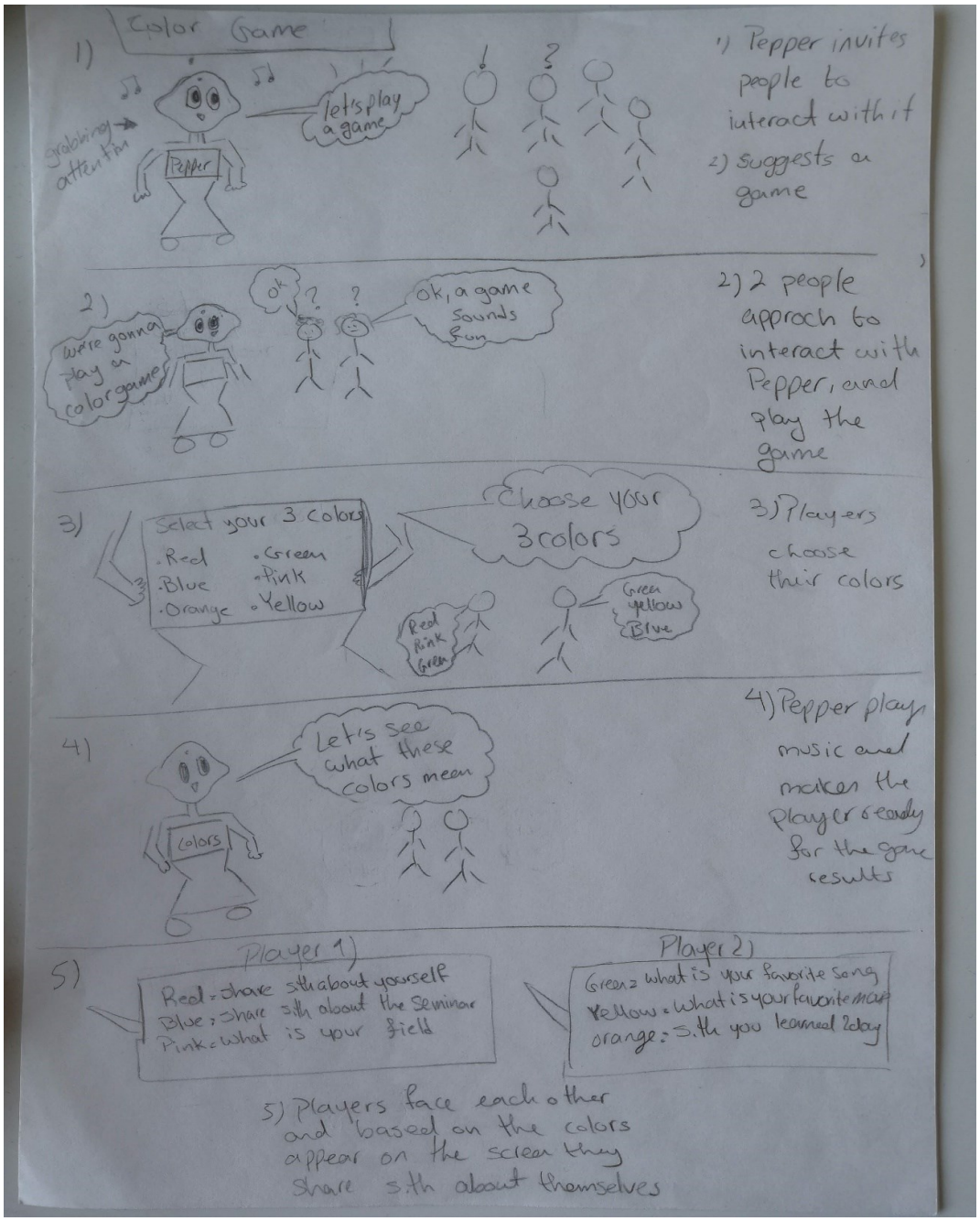
Appendix K.2 Speed Networking Concept

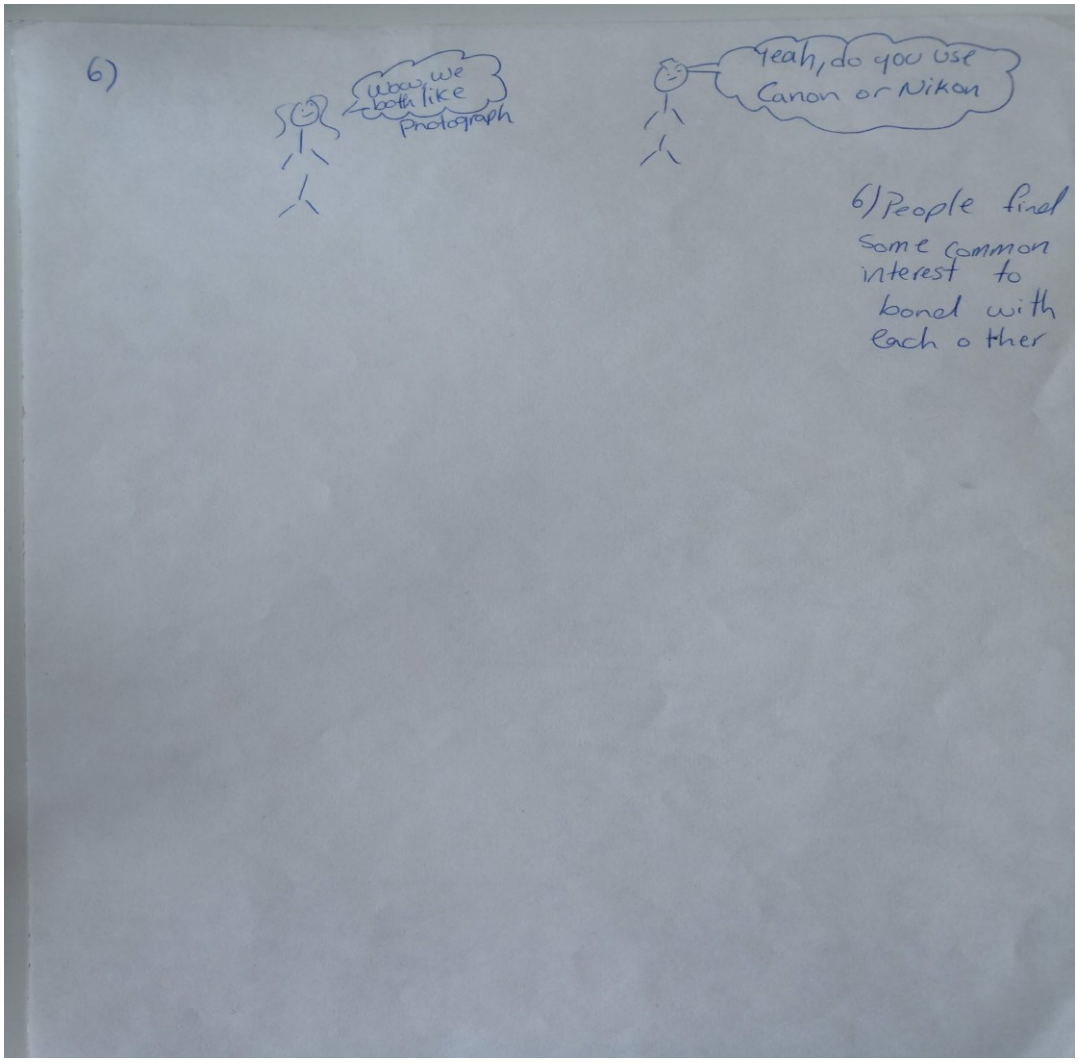


1


6)
I scheduled 2.30 for you and Sara to meet at room 201
Okay, great
6) Pepper gives the room # for ppl 2 meet
7)
Sara has also accepted to meet with you
great
7) Pepper notifies the other Person

Appendix K.3 Color Game




6)
Wow we both like photograph
Yeah, do you use Canon or Nikon
6) People find some common interest to bond with each other

APPENDIX L – Content Analysis Themes of User Field Trials

a. Content analysis themes of Pilot study

How do you socialize with others at events?

I approach others

I do not socialize with others

I talk to people sitting next to me

I talk to people I know from before

How would you think a social robot can be helpful in connecting people at events?

Exchange contact information
Entertainment
I Don't know
Guide people in the event
Introduce me to others

How would you think a social robot could act as an icebreaker at events?

Give the event Introduction
Performing entertainment
Guiding people

b. First field trial observation themes

Curiosity

Enjoyment

Honeypot effect

Unnoticed

Expected to do more

Hard time to use the robot

First field trial interview questions themes

How did you feel about Pepper welcoming you to the seminar? What did you like and dislike?

Fun
New
Joyful
Interesting
Not sure

What did you think about Pepper's entertainments (dance, hug, etc.)?

Nice
Short
Joyful
Didn't like
Entertaining

Have you ever attended a seminar or conference? How do you get to know other people at seminars or conferences?

I talk to people sitting next to me

I Approach people myself

I talk to people I know from before

I don't socialize

It is hard for me to talk to strangers

How would you think a social robot can be helpful in connecting people at events?

Guide people
Introduce people to others
I don't know
Better robotic implementations
Exchange information

How would you suggest a social robot to act as an ice-breaker at event?

Register People in the beginning of the event

Introduce itself

Provide entertainment

Guide people in the event

Give presentation about the event

c. Second field trial themes

Themes from the observation

Joy

Curiosity

Connecting with others

Honeypot

Themes from the interview questions

How do you feel about playing an icebreaker game with a help of a social robot?

Nice
Enjoyable
Fun

How do you think social robots can be helpful in connecting people at events?

Mutual Interest
Sharing Contacts
Collaborative tasks
Games

Was the game helpful in breaking the ice? How?

Fun
Learned new things about others

How do you think a social robot can act as an icebreaker at events?

Games
Share contact
Guide
Entertainment
Event INFO