Tampere University

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UNIVERSITY LANGUAGE INSTRUCTORS PROGRAMMING ROBOTIC LEARNING APPLICATIONS

Design and implementation of encouraging workshop experiences

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ABSTRACT

Natalia Mabel Quintero: University Language Instructors Programming Robotic Learning Applications: Design and Implementation of Encouraging Workshop Experiences
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People use technology in every aspect of their lives, and educational settings are no exception. Different devices, such as computers, tablets, smart screens, and even robots, have occurred for years in schools and universities. In recent years, educational robots have been used for different purposes, including supporting the learning of second languages, improving the social skills of students with autism, and developing communication skills, among others. Although educational robots have been utilized for some time, for the most part, the programming and implementation of activities on top of them are done by technology specialists. Additionally, educational professionals with no programming knowledge have been involved in programming robotic applications in fewer studies than educators with programming knowledge. Nevertheless, educators would be the ideal learning activity designers since they better know the pedagogical content and their students' needs and possibilities.

This thesis project aimed to design and implement a series of encouraging programming workshops, where two language instructors from Tampere University learned to program the social robot NAO. University language instructors designed and implemented robotic applications that students could use to practice their speaking skills. The research questions were related to the expectations and needs of university language instructors towards programming a social robot for teaching languages, their perceptions of the benefits and challenges of programming by themselves, and their experiences of the programming workshops. Learning journal, focus group interview, and questionnaires were implemented as data collection methods aiming to respond to these questions. Initially, language instructors participated in a co-design workshop to collaborate in designing the series of programming workshops. After being created, language instructors evaluated the programming workshops, assessed their benefits and challenges, and suggested possible improvements. During the workshops, language instructors designed and implemented robotic activities, which were tested by 35 students of Finnish I and Finnish II language courses.

The main findings of this project show that hands-on programming workshops, where participants can implement the activities by themselves, are a fast and easy way to learn to program a social robot. Additionally, some aspects that help maintain motivation during the sessions include having concrete and clear goals, observing progress, learning something new, and having a precise schedule. On the other hand, some of the challenges experienced by the language instructors are related to NAO not responding as expected, the overwhelming feeling when visualizing programming software for the first time, and previous knowledge regarding text-based programming languages. In the future, language instructors would like to use NAO with beginner students if the activities presented respond to a clear objective. Moreover, activities should be delivered within a context, providing students with a meaningful learning experience. However, language instructors expressed concerns about how NAO could influence students' speaking skills. The robot's speech recognition still needs further development, and currently, the robot can not recognize diversity in accents, the stress of words, intonations, speech speed, and complex sentences.

The results of this research project contribute to the previous literature about the role of educational professionals in programming social robots. Moreover, the research project aims to provide further knowledge on using robots for language learning with adult learners, which is currently limited. In addition, the research concludes with 12 implications for designing and implementing encouraging programming robotic learning application workshops for educators, including conducting a co-design workshop, establishing clear and concrete objectives for the participants, and generating hands-on and collaborative opportunities with a purpose.

Keywords: Social Robots, Robot-Assisted Language Learning, Human-Centered Design, User Experience, Service Design, Visual Programming Languages, End-User Programming.

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

PREFACE

"*Alone we can do so little; together we can do so much.*" - Helen Keller.

My thesis project had ups and downs, as in every process. However, doing my thesis was one of the most important learning processes of my entire education, and I am so glad that everything happened the way it did. Starting with a collaborative process that did not work, looking for new collaboration partners, and redefining my thesis topic were learnings that made me grow and will help me in my future endeavors. I want to honestly thank my wonderful supervisor, Aino Ahtinen, who was present and supported me in each phase of my thesis, providing encouraging words and actions and trying to find solutions and ways to proceed with this project. Without Aino's support and encouragement, this research process would definitely have been harder and less motivating.

I chose Helen Keller's quote because I think that the best approach is when different disciplines work together to get valuable and meaningful results. In my thesis, the collaboration with Utelias-Curious Technologies Ltd and the Language Centre of Tampere University allowed us to work together to create a series of encouraging programming workshops that aimed to teach language instructors to program the social robot NAO. I want to thank Utelias-Curios Technologies Ltd for providing a really interesting topic as well as supporting my thesis. To the two language instructors, I would like to say that nothing of this process would have been possible without them, and I am genuinely grateful to have collaborated in this research with such caring and committed people who were highly motivated to learn and eager to participate in this research actively. Thank you so much to both of you!

I also would like to thank all the students from Finnish courses who participated in testing the activities with NAO and gave their valuable feedback. In addition, I want to thank the whole Robostudio team, who were available to try to solve and help in every aspect needed for my thesis, so thank you all for that. Moreover, I want to thank my fantastic supervision group, Graduation Team, who were present at each monthly meeting listening and giving advice about my research. I hope that I was also able to contribute somehow to yours. Additionally, I would like to show my gratitude to Tampere University, who supported and allowed me to complete the master's degree in Human-Technology Interaction, which seemed so unreachable.

Last but not least, I would like to thank my Finland-based and Argentinian-based families, including my dad, siblings, nephew, friends, and partner, who have been supporting and encouraging me during this research process, each of them in different ways, and were an unconditional pillar during this time.

19 - Mar - 2023

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1 Introduction

This chapter includes the background and motivation for conducting this research and explains essential concepts including *social robots, robot-assisted language learning, human-centered design, service design, user experience, visual-based programming languages,* and *end-user programming*. Additionally, the objectives of this research and research questions are defined. Ultimately, the structure of this thesis is described.

1.1 Background and Motivation

Technology is used in every aspect of our lives, and educational settings are no exception. Different devices such as computers, tablets, smart screens, and even robots have been taking place for years in schools and universities. A *robot*, defined by the International Organization for Standardization (2021), is a mechanism that can be programmed to perform locomotion, manipulation, or positioning with a degree of autonomy, which means the ability to complete different actions without human intervention.

There are different kinds of robots; however, in the scope of this thesis, the focus will be on *social robots* explained by Hegel et al. (2009) as a robot that has two main aspects, technical aspects and social aspects, being the latter the core purpose of social robots. Hegel et al. (2009) implied that a social robot behaves socially in a specific context and, additionally, it needs to have an appearance that shows that it can be social with any user. According to Hegel et al. (2009, p. 173), "*artificial emotions, BDI (belief-desire-intention)-architectures, joint attention mechanisms, and modules for speech recognition and production are functions that produce and alter social interaction*." Moreover, social robots have been defined by Gallagher (2007) as robots created to interact with humans or with other robots in a way that looks similar to human-human social interactions. Gallagher (2007) states that a social robot can have different designs and looks depending on whether it is designed for specific or multiple situations and actions. From 2013 to the present, new social robots designed show more diversity in their embodiment. They generally have fewer degrees of freedom to make them less expensive and easy-to-move robots (Mahdi et al., 2022). In 2021, socially interactive robots were classified by the International Organization for Standardization as a category under *service robots*, which are robots for personal or professional use employed to perform practical tasks for humans or equipment. Some personal uses could be handling or serving items, transportation, physical support, and guidance. Professional uses include inspection, surveillance, transportation, and guidance.

In recent years, educational robots have been used for different purposes including supporting the learning of second languages (van den Berghe et al., 2019), improving the social skills of students with autism (Othman & Mohsin, 2017), and developing their verbal communication skills (Silvera-Tawil et al., 2018), among others. Social robots used in education have had three prominent roles (Belpaeme, 2018), including tutors, peer learners, and novice learners. When the robot acts as a tutor, teacher, or teaching assistant, it provides direct learning support to an individual or group of students via tutorials, supervision, and small clues. Robots behaving as peer learners or companions tend to be less intimidating to the user, providing motivational and encouraging support to learn the content. When a robot acts as a novice learner, the student is the one that takes the teacher role and instructs something new to the robot, and this interaction results in improving students' confidence and learning outcomes.

Although social robots have been used in education for some time, educational professionals with no programming knowledge have been involved in programming robotic applications in fewer studies (Kay & Moss, 2012; Kaya et al., 2017) compared to educators with programming knowledge (Major et al., 2011; Major et al., 2014; Zhou et al., 2015; Chambers & Carbonaro, 2003; Kucuk & Sisman, 2018). Furthermore, activities on top of educational robots are usually designed and implemented by technology specialists. However, educators would be the ideal learning activity designers since they know the pedagogical content, their students, their needs, and their possibilities better. *End-user programming* is called to the function done by a person who aims to program based on their own interest and needs, rather than aiming to produce commercially available products (Ko et al., 2011; Burnett, 2014). It has also been defined by Ajaykumar et al. (2022) as a research area that aims to allow end-users who are not robotics engineers to modify, customize, and implement robotic technologies, for example, social robots, according to their needs. Considering the mentioned research area, educators could be end-user programmers using their pedagogical knowledge and acquired programming skills to create robotic applications that respond to their and their student's needs. However, starting the programming process can be challenging for educators. Nowadays, robots offer diverse possibilities and plenty of programming languages that can overwhelm novice programmer educators. Therefore, programming workshops where they can learn in collaboration with others and be guided in the process can be a beneficial approach.

This thesis project aims to design and implement a series of encouraging programming workshops, where language instructors from *Tampere University* will learn to program the *NAO* robot to create activities that could be used in their teaching activities. The robot will be incorporated during language classes teaching Finnish as a second language. University language instructors will design and implement robotic applications that will then be tested with target students, who are international students at Tampere University, taking the language courses Finnish I or Finnish II. University instructors are the ideal designers to create the learning activities as they know the content to be covered, the teaching strategies that can be utilized, and the specific needs of their students. In addition, creating activities involves many modifications, as these need to be adjusted when the students are progressing in their learning. Therefore, providing the necessary content that allows language instructors to create their own activities could be a sustainable solution.

The whole research project will be conducted following a *human-centered design* (HCD) approach, defined by the International Organization for Standardization (2019) as a research approach that seeks to create usable and useful systems that focus on the users, their needs, and their requirements by applying different design techniques. The HCD approach enhances user satisfaction and aims to achieve better *user experiences*, meaning the user's perceptions and responses from interacting with the system (International Organization for Standardization, 2019). University language instructors will be actively involved in the design process from the beginning, providing feedback about their needs and expectations for the programming workshops. The designed programming workshops will aim to respond to all the requirements specified by the educators.

Another approach that will be used to outline the research is *service design* (Stickdorn et al., 2018). In concordance with HCD, it looks to incorporate the users in the design process; however, it is more comprehensive than knowing their needs and requirements. Instead, service design aims to include the users in a collaborative and interdisciplinary co-design where they are active members of the design process. In addition, service design looks to create design ideas that can be achieved in real life and produce a sustainable solution that responds to the needs of all stakeholders involved in the service.

The social robot NAO has been chosen as a research platform since it is a robot that can be programmed by using graphical interfaces that do not require previous programming experience. University language instructors will use *visual-based programming languages* to program NAO. The language is an easy-to-use programming language that allows users to drag and drop different icons (function or behavior) to create the robot program (Bravo et al., 2017). In this research, NAO will act as a RALL robot; *robot-assisted language learning* (RALL) is a research field that studies the use of social robots for language learning (Kouri et al., 2020). Robots can assist in learning native and second languages in verbal and non-verbal communication modalities such as, for example, sign language (Randall, 2019).

Another reason for choosing NAO is that it has been used in previous research as a peer or teacher assistant where the benefits of using a social robot for teaching languages have been studied, finding the robot's presence as a motivation for students (van den Berghe, 2022). Ahtinen & Kaipainen (2020, p. 9) noticed in their study:

"*It adopted a positive role as an encourager and learning companion for the pupils. It was able to create positive atmosphere for learning in class, and pupils considered it as a motivational "dude". Pupils were willing to learn with the robot throughout the research period and did what it asked them to do. We consider the learning robot as an assistant for the teacher with its own strengths, with a lot of potential to be used in various ways at school and for multiple projects.*"

The results of this research project will contribute to the existing literature about the role of educational professionals in programming social robots. In previous studies conducted by Chambers & Carbonaro (2003) and Kucuk & Sisman (2018), educators with programming knowledge learned to program using LEGO robots and the Robotis Dream educational robotics kit. In these experiences, educators worked collaboratively to resolve different challenges and implement activities and a final exercise.

The research process will conclude with guidelines for designing and implementing encouraging programming robotic learning application workshops for educators. The whole research process will be conducted in person in *Robostudio*, a multidisciplinary co-learning and co-working space located at Tampere University, Hervanta Campus, which can be used to work with social robots for educational and research purposes.

This thesis project is a collaboration work between *Utelias-Curious Technologies Ltd*, a Finnish ed-tech company creator of the language learning app *Elias Robot*; the *Language Centre* from the Faculty of Education and Culture of Tampere University, and the *Faculty of Information Technology and Communication Sciences* from Tampere University.

1.2 Research Objectives and Research Questions

This thesis work aims to design and implement a series of encouraging workshops where university language instructors will learn to program the social robot NAO. The research questions are:

RQ1: What are the expectations and needs of university language instructors towards programming a social robot for teaching languages?

RQ2: What are the university language instructors' perceptions of the benefits and challenges of programming a social robot by themselves?

RQ3: What are the university language instructors' experiences of the programming workshops?

The first research question is expected to be answered with the information obtained from the co-design workshop, where we will work with university language instructors to design programming workshops that fit their needs and expectations. The second and third research questions are aimed to be answered with the information gathered from the group interview done with the language instructors after the programming workshops have been conducted, and the learning journal filled by the professionals who participated in the programming workshops. In addition, all the robotic applications implemented by the language instructors will be tested by target students of Finnish courses who will give their feedback about the experience of using a robot for language learning.

1.3 Structure of Thesis

The remaining part of the thesis is structured in the following way, chapter 2 includes the related work that helped to support the thesis work with studies done previously, containing two subsections robot-assisted language learning and educational professionals programming robotic applications. Chapter 3, Methodology, covers research methods, phases, and platforms utilized in the research. Additionally, research methods are divided into research approaches, data collection methods, and data analysis methods; meanwhile, research platforms has three subsections including NAO robot, Elias Robot app, and Choregraphe.

Continuing chapter 4 contains details of the user study, a co-design workshop that helped learn the user's needs and expectations, and co-design the programming workshops. The user study chapter includes the objective of the study, procedure, participants and ethical considerations, data collection methods, data analysis methods, findings, and summary. Subsequently, chapter 5, Design of the programming workshops includes design features and design justifications done with the learnings of the user study and the literature reviewed.

Chapter 6, Evaluation of the design, includes the objective of the study, procedure, participants and ethical considerations, data collection methods, data analysis methods, findings, and summary. Additionally, findings are divided into two subsections including findings of quantitative data and findings of qualitative data. Proceeding, chapter 7 contains the implications for designing programming workshops, and chapter 8 includes the discussion with three subsections summary of findings, discussion, and limitations and future work. Lastly, chapter 9 includes the conclusion of the research.

2 Related Work

This chapter includes the related work that supports and gives the basis for the thesis research. The chapter is divided into two sections, the first related to previous work linked to robot-assisted language learning, and the latter associated with how educational professionals have been involved in programming robotic applications.

2.1 Robot-Assisted Language Learning

Definition of RALL. The research field named robot-assisted language learning (RALL) studies the use of social robots that are utilized in different contexts to support language learning (Kouri et al., 2020). RALL is a subdomain of the research field named robot-assisted learning (RAL or r-learning); RAL also studies educational robots, however, these are used for general teaching purposes (Randall, 2019). The RALL concept was proposed in 1986 by Harwin, Ginige & Jackson (1986) who argued that the physical interaction possible between the learner and the robot was an advantage compared to software-based computer-assisted language learning. Some of the common tasks of these robots are teaching vocabulary (Kanda et al., 2004), helping the learner practice reading and writing skills, as well as teaching grammar and sign language (Vogt et al., 2019). RALL robots have been used with children as students feel motivated to learn a new language in the presence of a robot. In addition, there is some evidence of better learning outcomes when using a robot, as seen in the studies conducted by Han (2010) and Kanda et al. (2007).

Language teaching methods. Lin et al. (2022) did a review of 22 studies where RALL robots were used, and they found that robots have been mainly employed with primary school learners (n=11), followed by preschool learners (n=4), higher education learners (n=4), and secondary school learners (n=3). The authors' review focused on finding what were the design features that allow learners to have positive learning outcomes when using RALL robots for oral interactions. They also found that the most popular language teaching methods chosen to create RALL robots' oral interactions were communicative language teaching (n=13), followed by teaching proficiency through reading and storytelling (n=7), and total physical response (n=6). *Communicative language teaching* has been defined by Savignon (1987) as a teaching approach that considers communication as the primary function of language; hence it states that the best results are achieved when language is taught by communicating. A similar method where the aim is to develop fluency in speaking skills is *teaching proficiency through reading and storytelling*. By implementing this method, both teachers and learners use engaging and comprehensive stories in order to gain knowledge about the language (Muzammil & Andy, 2017). The latter-mentioned method, *total physical response*, has been explained by Er

(2013) as a language teaching method proposed by Asher that aims to teach language through both speech and physical movement. In this method, learners are active listeners and performers of the actions that the teacher proposes; additionally, they are animated to speak only when they feel capable to do it. Some of the actions proposed by the teacher are verbal prompts and movement games, after those proposals, the learner responds physically employing the movements initiated by the teacher. Regarding the interactive task design, Lin et al. (2022) found that tasks that aimed at oral interactions included dialogue (n=11), acting in stories (n=8), back-and-forth questions and answers (n=7), playing different roles (n=5), drill (n=4), and action commands (n=3).

Roles of RALL robots. Lin et al. (2022) found that the most common role of the robot was a dialogue interlocutor (n=12). In those studies, there were fixed phrases or sentences that the robot could use to conversate with the learners. The following most used role contented by the robot was a role-play character, where a story was presented and the robot acted as one of the main characters in it (n=9), followed by a companion robot that sang, danced, and entertained the learner by playing or showing them pictures (n=5). However, a robot assistant that aimed to help the teacher was found in only one study. In addition, the primary function of the robot was teacher talk with tasks such as skill training and affective feedback.

Learning outcomes. With the literature reviewed, Lin et al. (2022) identified the learning outcomes of robots' oral interactions including academic achievement, increments in concentration, and major abilities in picture naming. Additionally, the authors were able to recognize that robots mainly were used to "*facilitate bi-directional communication by initiating or engaging in verbal, gestural, and physical interactive processes to allow learners to practice receptive (e.g., listening and reading) and productive (e.g., speaking and writing) language use*" (Lin et al., 2022, p. 12). Moreover, robots were used with the company of tablets and human facilitators who provided learning and technical support during robot-learner interaction.

Uses of RALL robots. Van den Berghe (2022) reviewed 83 studies to evaluate what languages robots have been used in previous studies. The author stated that one of the most positive aspects of robots is that they have the capacity to speak several languages. Their review wanted to discover if robots have been mainly used to teach L1 (native language), L2 (foreign language), or a mix of them. In their review, van den Berghe (2022) found that 24 studies used robots to teach L1 during the learner-robot interaction, and L2 was only used for specific target words. In most of the studies (n=46), the robots used the L2 of the learner during the interaction. In these situations, robots used the L2 to tell the students stories or conversate with them. The rest of the reviewed studies (n=13) used an approach where both L1 and L2 were used. Some studies used the approach where one person maintains one language, for example, the robot would use the L1 of the learner and the teacher the L2 of them. However, only a few studies that used the main advantage of the robot of using multiple languages at the time have been conducted.

Benefits of RALL robots compared to other technologies. Social robots have benefits such as their physical and social presence compared to other technologies such as tablets and computers (van den Berghe, 2022). Their physical embodiment could be one of the main reasons to be effective tools in general education (Belpaeme et al., 2018) and language education (Lee & Lee, 2022). Furthermore, many social robots have arms that allow them to make gestures, which are important for communication, as gestures are an important component of message's meaning (van den Berghe, 2022).

Van den Berghe et al. (2019) did a review of previous studies. They found that both the manipulation of real-life objects (Kersten & Smith, 2002) and the use of the body and gestures (Mavilidi et al., 2015; Rowe & Goldin-Meadow, 2009; Toumpaniari et al., 2015) have been beneficial for children’s vocabulary language learning. Both beneficial aspects are possible to be covered with social robots. Based on those findings, van den Berghe et al. (2019) reviewed studies that assessed the motivational aspect of the robot compared to other technologies. They found that preschool children, assisted by a robot, were able to participate with plenty amount of energy in reading activities (Hsiao et al., 2015).

Moreover, preschoolers who were learning English as a second language showed minimum anxiety levels, and an improvement in their motivation and engagement after they have interacted with a robot in multiple occasions (Alemi et al., 2017). Furthermore, students working with *NAO* in a second language (English) conversation class participated more and were more satisfied compared to when they did it with a computer (Shin & Shin, 2015). Lastly, in Westlund et al. (2015) study, preschooler learners chose to learn with a robot instead of a human teacher or a tablet. To summarize, van den Berghe et al. (2019) concluded that robots appear to have a favorable repercussion on students’ motivation compared to other forms of technology, such as tablets or web-based programs.

Use of a robot to teach L2 to children. An example of a study using a robot to support the learning of languages was done by Ahtinen & Kaipainen (2020), who conducted long-term research in a Finnish school where students were learning English as a second language. In this study, the language learning app *Elias Robot app* was used in the humanoid social robot *NAO* which can, for example, walk, speak, recognize speech and faces, as well as make gestures. During the four months of study, three language teachers used NAO with the whole class or small groups of 3-4 pupils. The researchers collected data from 20 pupils, three language teachers, and 18 parents. Some of the methods to collect data were a) observations, b) online diaries, c) online questionnaires to teachers, d) online questionnaires to parents, and e) interviews with teachers. The data was analyzed doing affinity diagrams, generating seven main categories and 37 sub-categories.

Ahtinen & Kaipainen (2020) found that the pupils felt happy and motivated to learn with NAO, completing the tasks that it asked them to do. In the beginning, just the presence of the robot was enough to excite the students. However, as time passed, teachers had to imagine and plan how to incorporate the robot into their teaching activities. Nevertheless, researchers found that the learners remained highly motivated to learn with the robot during the four months that the research lasted. The researchers, as well as previous studies reviewed by van den Berghe et al. (2019), found that the physical presence of the robot, as well as the interaction in and with the learner's physical environment, are key features of RALL robots.

On the other hand, Ahtinen & Kaipainen (2020) found that some frustration was caused for teachers and some pupils when the robot had technical problems, causing them to lose time. In addition, occasions where the speech recognition did not work as expected were present, making some students refuse to interact with NAO again. In the future, according to teachers' perspective, different guidelines would be needed to present models of how the robot can be incorporated into the classroom, for what kind of activities, and its frequency of use.

Use of a robot to teach L2 to adults. Similar research, with the difference that in the latter one, the target group of users was adults, was conducted by Engwall & Lopes (2022). In their research, the authors wanted to study how robot-learner interaction in RALL robots is influenced by the interaction behavior of the robot. They studied the role of robots in previous studies, however, they found that more research needs to be done on adult learners. The authors considered that there might be differences regarding learning preferences compared to children, since adults have already experienced further real-life interactions; hence, they would need more realistic interactions which are relevant to them. Based on previous studies, they found that there are different types of robots including *toy-like robots* such as *Mindstorm* or *iCat*; *face or belly screen robots* such as *Robosem* or *iRobi*; *humanoid robots* such as *Mec Willy* or *NAO*; and *robotic heads* such as *Mero* or *Furhat*. Additionally, robots are used with different teaching strategies such as a) *practice* using learning resources following multimedia-based education or the audio-lingual method; b) *physical interaction*, where students can either control the robot or robots are used as an example to demonstrate gestures and movements to students; c) *communication practice* where a robot is used to, for example, ask and answer questions or practice conversations; d) *role play* where the language learning is based in a task and build up establishing a relationship between robot and learner; and e) *collaborative language learning* that aims to have a collaboration between two or more learners interacting with the robot, or between the learner and the robot.

In addition, Engwall & Lopes (2022) discovered that robots had different roles while being used to learn languages. The first role was defined as a *teaching assistant,* where robots are used in traditional classrooms as a motivational resource that a human teacher manipulates. The second role found was *tutor,* where robots interact with the learner and teach them some content without the presence of a human teacher. The third role was *peer, partner, opponent, or tool robot* which are robots that have a second language knowledge similar to the learners. Engwall & Lopes (2022, p. 1284) stated that "*The peer robot is 'learning' the language together with the learner; the partner robot interacts with the learner to solve a task using the target language; the opponent robot competes with the learner to solve a task in the target language; and the tool robot is controlled by the learners in the target language.*" The fourth role found was the *learner robot* where the learner teaches something new to the robot; and the fifth and last role was *social companion robots* where robots are used to practice the second language by interacting with the learner in a social form, rather than proposing explicit exercises.

Based on the learnings from previous studies, the authors were able to define implications for RALL robots applied to adults, including utilizing a teaching strategy in concordance to human-human interactions as task-based language learning, communicative language teaching, and collaborative language learning. In addition, learners should be able to define the robot's role, and the robot should support the use of both verbal and non-verbal communication promoting social exchange rather than the rewards given during the practice. Considering the implications mentioned above, they decided to conduct a study with the robotic head Furhat, seen in *Figure 1*, where two adult learners of the Swedish language conversated with the robot about topics including personal matters and languages. The robot displayed four behaviors: a) *interviewer* where the robot interacted with one of the learners at the time and asked a set of defined short questions. In this role, the robot did not give information about itself, even when learners asked for it; b) *narrator*, where the robot presented activities such as storytelling, quiz, and small talk where robots, either Furhat or others, were the main protagonist, the objective of the narrator robot was to relate the activities with its own story or opinion; c) *facilitator*, where the robot promoted the interaction between both learners, encouraging them to discuss topics; and d) *interlocutor*, where both learners and the robot shared their personal stories and opinions about different topics and all of them commented on each other. As this setting was aimed to be more personal, Furhat called the learners, their home countries, and their first languages by name.

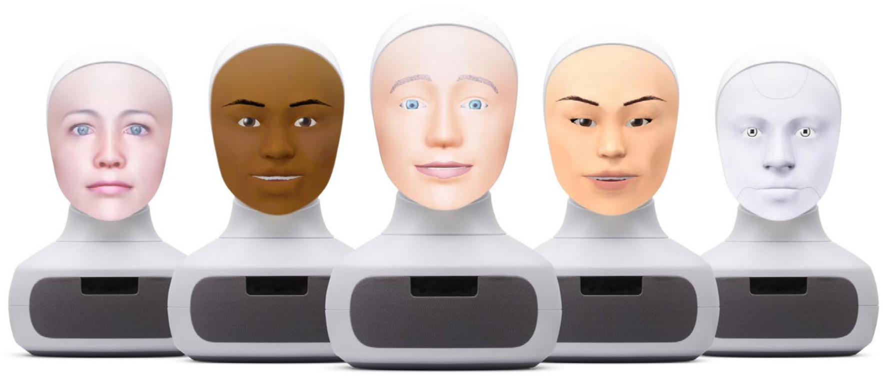

Figure 1. Furhat robot (source: *https://furhatrobotics.com/furhat-robot*)

The user study in the research of Engwall & Lopes (2022) was conducted with 33-second language learners. During the study, the different data collection methods utilized were video recording, audio recording, and learners' questionnaires. The latter assessed the learning effectiveness and the robot's interaction behavior using a 6-point Likert scale. From the study, the authors found that the conversation practice was suitable for adult learners, therefore, RALL robots may be used successfully in the future with adult learners of second languages. Regarding robot behavior, they found that the interviewer behavior was the most preferred, followed by interlocutor, where both behaviors aimed to teach by communicative language teaching. Moreover, learners preferred when the robot leaded the discussion and prioritized the robot-learner interaction; however, they also found that the behavior should be adapted based on the learner's age, gender, language proficiency, and vocabulary familiarity.

Additionally, they found that using a collaborative setting, where two students can interact with the robot at a time instead of one single student interacting with the robot, differed between sessions and group of learners. During narrator, facilitator, and interlocutor behaviors, learner-learner interaction was an important factor as learners collaborated to understand the robot or to create together answers that the robot could understand. Although the collaborative setting was seen as a benefit, not extensive evidence was found about making the robot provide a more personalized approach calling learners by their names and mentioning their home countries or native languages. However, they could observe that learners were curious about Furhat and did ask it personal questions, which the robot only answered in the conditions of narrator and interlocutor. In the learners' questionnaire, the learners showed their appreciation when the robot gave those answers. Therefore, the authors could recognize that creating a robot background story is important in social robot-learner interactions.

Moreover, the students perceived a feeling of repetition and rated the robot lower when it asked similar questions as the ones done in previous sessions. Hence, for authors, a robot that can track topics covered with a particular learner and their answers is required in order to avoid topic repetition and personalize the conversations based on learners' answers. Although the explained research was really interesting, the authors recognized the need to conduct further research where RALL robots are used with adult learners.

Further studies with adult learners. Although there is no extensive research conducted where robots were used to support the learning of native or second languages with adult learners, there are some previous studies. Kouri et al. (2020) explored the advantages of customized language robots that aimed to support immigrants in their professional development and adjustment to their work environments. In their research, ten immigrants used the NAO robot, on average three times, in their workplaces to support their Finnish language learning. The authors found that customization of the robot is needed based on the learner's needs and their work environment. In addition, successful RALL robots need a positive attitude from the person learning and also from the work environment. Furthermore, they found that the present of a human facilitator is required in order to support the implementation and success of the robot.

Kanero et al. (2022) conducted a study where 102 Turkish adults learned eight words in English either with a NAO robot or with a human tutor. The authors found that learners can learn from social robots in a similar form as they would do it with human tutors. However, they also discovered that learners with negative attitudes towards robots obtained inferior learning outcomes in the robot tutor condition. Additionally, they found that anxiety can impede learning when the tutor is a robot, but this was not visible when the tutor is a human. With those findings, the authors highlighted the importance of recognizing diversity among learners. They also stated that careful considerations are needed in order to reduce learners' anxiety and negative attitudes towards robots before these technologies are introduced to learners.

Engwall et al. (2022) conducted further studies with the robot Furhat and the four behaviors introduced above including narrator, interviewer, interlocutor, and facilitator. The main objective of the latter study was to investigate if verbal, vocal, and facial information could be used to identify language learners with low engagement in robot-learner conversation practice. The robot talked with a pair of adult learners at the time, and the authors collected 50 conversations. The authors found that the interaction strategies, also called behaviors, influenced learner engagement. They discovered that interlocutor and facilitator behaviors were most successful at engaging learners. Engwall et al. (2022, p. 27) stated that: "*However, the differences between robot interaction strategies are overshadowed by differences between learners and within learners. The learners did not only differ in how engaged they were in general, but also in their relative engagement with different robot interaction strategies.*" Based on those findings, the authors highlighted the importance of being able to identify learners with low engagement instead of trying to design a robot interaction strategy to engage every possible learner.

Iio et al. (2019) conducted research where nine female university students from Japan used a robot to practice their speaking skills in English. The participants used the robot for 30 minutes per day for seven days. After using the robots, students' speaking skills were augmented, especially an improvement in their accuracy while speaking, fluency, and pronunciation was seen.

2.2 Educational Professionals Programming Robotic Applications

Although robots have been used in education for a long time, educational professionals with no programming knowledge have been involved in programming robotic applications in fewer studies (Kay & Moss, 2012; Kaya et al., 2017) compared to educators with programming knowledge (Major et al., 2011; Major et al., 2014; Zhou et al., 2015; Chambers & Carbonaro, 2003; Kucuk & Sisman, 2018). Educators tend to not ready feel to use robots for education and that feeling can be a result of, as explained by Schina et al. (2020), the scarcity of specialized training for educators in educational institutions, the insufficient content of the training available, or other reasons. Schina et al. (2020) reviewed 38 scientific publications trying to discover what were the general requirements for the completion of educational robotics training, the duration of them, what were the trainer and trainee profiles, and what pedagogical approaches were usually followed. They discovered that most of the experiences documented were missing important information such as requirements, pedagogical approaches, or duration of training. In addition, they were able to identify the best practices documented in the literature reviewed including collaboration, materials, pedagogy, practice, and feedback/support.

Best practices for educational robotics training. According to Schina et al. (2020), it is important to *generate opportunities for participants to collaborat*e with each other; participants could work together to, for example, produce the final project needed to approve the training. In addition, participants could share solutions as well as teach each other how to solve diverse problems. *Exchanging feedback* is another strategy that follows the principles of collaboration, feedback could be given among participants regarding successful strategies that have been used, solutions to implementation challenges, as well as sharing resources and materials. These guidelines help to create a non-competitive environment where each participant can learn without stress and at their own pace.

In addition, *generating teaching materials* that can be used afterwards during their teaching classes has been an important factor. The authors also found that the best practices in educational robotics are the ones that *adopt a pedagogical approach* and incorporate it into the training. Another best practice is actual *practice*, meaning that educators should be encouraged to apply their technical and pedagogical skills as soon as possible. In order to achieve this, educators should participate in hands-on work involving assembling and programming the robot using programming software by themselves. Moreover, educators should *receive support* from the instructors/researchers during the training. After that, instructors should be able to visit teachers' classrooms to observe how the robotic applications are used with the students and provide technical support and extra help if the educators needed.

With the literature reviewed, Schina et al. (2020) concluded that educational robotics teacher training programs should incorporate a clear teaching methodology based on a pedagogical theory as well as justify their election. From previous studies, they found that pedagogical approaches are mainly based on constructivist and constructionist pedagogies. These approaches might be selected since learners in a constructionist learning environment can experience meaningful learning that involves a hands-on, collaborative, and constructive active environment. In addition, the authors considered that the training should also incorporate a *program description* that explains how the activities will be carried out, the total number of training hours, attendance hours, teaching practice hours, etc.

Previous studies incorporating constructivist and constructionist approaches. Two previous studies where constructivist and constructionist pedagogical approaches were selected as a basis for conducting the programming training were conducted by Chambers & Carbonaro (2003) and Kucuk & Sisman (2018). Chambers & Carbonaro (2003) designed a pilot course for current and future teachers, with two aims including to support curriculum technology integration by allowing students to design, build, and program *LEGO* robots; and to engage students in a constructionist learning environment where they could learn by doing. In their course, students worked both individually and in group settings, where collaboration among them was highly encouraged. Additionally, students were assigned eight task levels which they should complete throughout the course. Moreover, they were expected to complete a daily log of their reflections on discussions with other students, robotic projects, their debugging processes, ideas of how to use the activities in their classrooms, and reflections on the reading materials. Chambers & Carbonaro (2003) found that the course was successful, however, there were some technical problems and students felt at times pressed by times and frustrated. Nevertheless, all the students were able to learn the programming language as well as to program the robot. They discovered that the final exercise level was the hardest one and the one that presented more challenges for the students, however, with the support of other learners and their teacher, they were able to complete the exercises.

The most recent study, conducted by Kucuk & Sisman (2018), was a study where 15 pre-service teachers participated in teams of 3-4 teachers and completed activities using the *Robotis Dream* educational robotics kit that has four levels, including introduction and assembly of parts, activities to design robots that can detect objects around them, and creation of more advanced robots during third and fourth levels. The training kit is used with C programming language, a text-based programming language. After the teachers had completed the activities, an interview was conducted. From those, the authors found that participants perceived that they were able to learn robotics design and programming easily after they have acquired some experience, although it did require a higher cognitive load at the beginning. Moreover, they considered the learning approach, learning by doing and by experience, as a satisfactory learning method that allowed them to work on teams and produce a final robot product. They mentioned that working in groups was an efficient and productive process, where they were able to boost their creativity.

As expected, participants also mentioned there were some challenges, however, these were overcome by trying to maintain their individual motivation to learn. In addition, peers and course instructors played an important role in resolving the challenges. Finally, participants considered that receiving training in robotics design and implementation was important for their professional development and a form of adapting to emerging technologies. Training also allowed them to wonder how robots could be used in their own fields.

Visual-based programming languages. In concordance with the previous authors, Bravo et al. (2017) recognized that robot programming can be a challenge to teachers and students who do not have previous experience in programming or knowledge of text-based programming languages. Text-based programming languages, such as *Python*, *C++*, and *Java*, are languages that require the knowledge of specific syntax and semantics of the language in order to create a robotic program. However, text-based programming is not the only language that allows people to control a robot. Visual-based programming languages allows users to drag and drop different icons (function or behavior) and connect them with each other to create a robot program (Bravo et al., 2017). As explained by Bravo et al. (2017), visual-based programming is beneficial for non-programmer users and currently, a lot of robot programming software in educational robotics uses this kind of programming language. Although visual-based programming is simpler than text-based programming, the first one still requires some basic knowledge of programming skills such as loops and conditional statements.

End-user programming. Result of a simpler programming tool, visual-based programming can be highly useful for *end-user programmers*. End-user programming has been defined as "*an emerging research area that seeks to enable end-users of general-purpose robotic technologies who are not robotics engineers to re-task and customize robots according to their needs*" (Ajaykumar et al.,2022, p. 1). In addition, end-user programming allows users to modify and create robotic applications within their contexts. By reviewing previous literature, Ajaykumar et al. (2022) were able to identify four phases of end-user programming including a) *initialization and setup* where users may prepare the required hardware and install the desired software to start programming; b) *authoring*, where depending on the programming system, users can modify or create robot capabilities, to specify the structure and logic of a program using prespecified robot actions, such as grasps or spinning, as well as create new or modify sequence of actions; c) *editing and debugging*, where users can use editing tools of the programming program to refine the program, edit it, and remove any errors or irregularities; and d) *verification*, when the user verifies that the program works correctly when executed on the robot.

Moreover, Gorostiza et al. (2011) highlighted that end-user programming not only allows increasing the robot's capacity but also, and more importantly, end-user programming permit end-users to learn how to program a robot while enjoying and having fun during the process. In addition, they mentioned that creating robotic programs could be interesting if the programming software and interface provide a natural and easy-to-learn interaction platform.

Further uses of end-user programming. The term end-user programming is used with other technologies aside from robots. End-user programming is called to the function done by a person who aims to program based on their own interest and needs, rather than aiming to produce commercially available products (Ko et al., 2011; Burnett, 2014). In their case study, Kross & Guo (2019) collaborated with a local organization to teach adults with low-income data science. The program aimed to provide those adults with the basic data science skills that would allow them to obtain entry-level jobs and become end-user programmers.

Leitner et al. (2013) conducted a study evaluating smart home scenarios and their relation to end-user programming. The study was part of a project that aimed to develop technology for older adults to extend independent living in their habitual homes. In this evaluation, a prototype that permits the simulation of end-user programming tasks was implemented and tested compared to two commercially available products.

2.3 Summary

For some time, social robots have been used to support students in learning first and foreign languages. The most common tasks of these robots are teaching vocabulary (Kanda et al., 2004), helping the learner practice reading and writing skills, as well as teaching grammar and sign language (Vogt et al., 2019). Previous studies have shown that the use of RALL robots with children is beneficial as students feel motivated to learn a new language in the presence of a robot, and in addition, there is some evidence of better learning outcomes when using a robot (Han, 2010; Kanda et al., 2007).

However, as shown in the long-term study of Ahtinen & Kaipainen (2020), the robot itself can be motivational for the students at the beginning, but as time goes by, teachers should find new ways of incorporating the robot into their teaching activities. In addition, in this study, teachers mentioned the need for guidelines that outline how the robot could be used in the classroom, the frequency of the use, and for what activities.

Although extensive research has been conducted on the benefits of RALL robots with children, only some studies related to the use of robots with adult learners exist. Engwall & Lopes (2022) mentioned that children learners and adult learners might have different requirements and expectations regarding the presented activities by the robot, as adult learners have further previous experience and might wait for meaningful interactions similar to the ones they have experienced in their real life. The authors conducted a study where the robot Furhat was presented and used by adult learners with four different behaviors: narrator, interviewer, interlocutor, and facilitator. They found that the interviewer's behavior was the most preferred, followed by the interlocutor, where both behaviors aimed to teach by communicative language teaching. Consequently, it was preferred when the robot led the conversation and prioritized robot-learner interaction. They also found that using a collaborative setting, where two students can interact with the robot at a time, was the most beneficial format for the interaction.

While social robots have been used in education for some time, educational professionals with no programming knowledge have been involved in programming robotic applications in fewer studies (Kay & Moss, 2012; Kaya et al., 2017) compared to educators with programming knowledge (Major et al., 2011; Major et al., 2014; Zhou et al., 2015; Chambers & Carbonaro, 2003; Kucuk & Sisman, 2018). However, the emerging research area of end-user programming (Ajaykumar et al., 2022) is bringing opportunities where end-users can create and modify robotic applications according to their needs and expectations. By using tools such as visual-based programming languages, educators are able to design and implement robotic programs based on their and their students' needs and strengths that help them to support their teaching activities.

In their literature review, Schina et al. (2020) were able to identify documented best practices for educational robotics training, including collaboration, teaching materials, pedagogy, practice, and feedback/support. The authors highlighted the importance of providing hands-on opportunities where teachers could start practicing their acquired skills early by designing and implementing robotic programs by themselves. Additionally, Schina et al. (2020) found that following a pedagogical approach that supports and helps to design robotic training is a good practice. The most common pedagogical approaches chosen by previous authors are constructivism and constructionism whose aim is related to allowing learners to build knowledge by doing and by example, learning from and with others, in an active environment that promotes collaboration and cooperation among learners.

All the literature reviewed helped to understand how RALL robots have been used in an educational context and the benefits of using them. In addition, the finding of the concept of end-user programming supported the idea that teaching educators to design and implement their own robotic applications is a proper approach. Moreover, the review of previous literature which highlighted the best practices when designing robotic teacher training, was beneficial when designing and implementing the robotic programming workshops, as all the considerations were contemplated to create and provide educators with meaningful learning experiences.

3 Methodology

The Methodology chapter includes an explanation of the different research methods utilized during the research process. In addition, the research approaches that outlined the research, *human-centered design* and *service design* are thoroughly described. Finally, the chapter also includes information related to the technical platforms with which the research was conducted, the social robot *NAO*, *Elias Robot app*, and *Choregraphe*.

3.1 Research Approaches and Methods

In this section, research approaches and methods utilized during the research are divided into three different sections: research approaches, data collection methods, and data analysis methods.

3.1.1 Research Approaches

During the conducted research, two main approaches were used *human-centered design (HCD)* and *service design.* The first one, HCD, has been defined by Norman (2013) as a design philosophy that looks to understand people and their needs which are intended to be accommodated by the design. This approach "*puts human needs, capabilities, and behavior first, then designs to accommodate those needs, capabilities, and ways of behaving*" (Norman, 2013, p. 8). As explained by Norman (2013), the understanding of those needs starts with observation as people are often unaware of their own needs due to being accustomed to their reality. The design process continues with rapid tests of ideas allowing designers to modify the selected approach and proposed solution after each try. The optimal result is products that truly meet people's needs and that provide good communication from the machine to the person, giving real-time information and feedback about the possible actions, what is currently happening, and what will happen shortly.

The HCD process explained in ISO 9241-210 has five iterative phases. The first one, *research*, aims to understand and specify the context where the design could be used. The second one, *analyze and specify*, seeks to specify the user requirements which could be answered by the design. The third one, *design*, looks to produce design solutions that meet user requirements. The fourth phase is called *evaluate* where the designs are evaluated assessing if user requirements are covered. After the first evaluation, the iteration process can start, returning to previous phases when needed, to redefine the design and guarantee that the user's needs are fulfilled. When the design solution responds to the user's requirements, the whole HCD is completed by the fifth and last phase, *launch.* A representation of the HCD process can be seen in *Figure 2*.

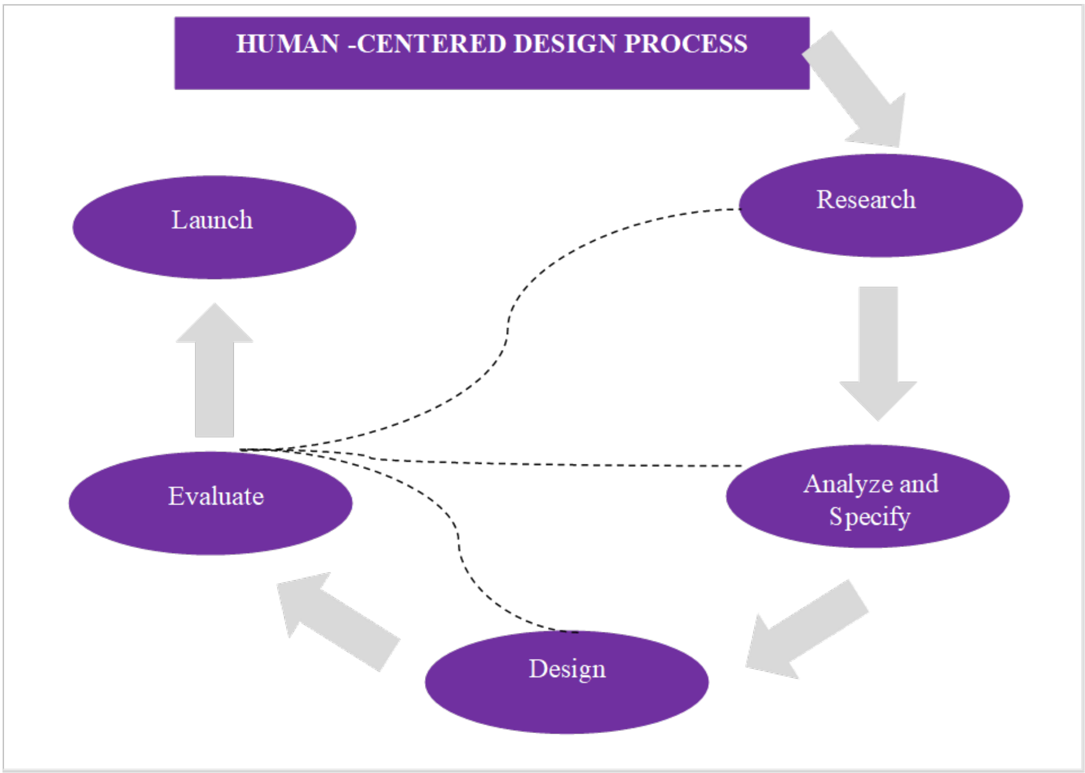

Figure 2. Human-centered design process based on ISO 9241-210

The second approach, *service design* (Stickdorn et al., 2018), is a research approach that relates to HCD in the sense that also considers the users as an important part of the research process. Additionally, in this research approach, all stakeholders who will be users of the product in the future, are invited to actively participate and collaborate in an interdisciplinary process to co-design the offered service or product. As well as HCD, service design is an iterative process that includes user research, design prototypes, and evaluation of the design. Service design aims to fulfill the needs of all stakeholders by providing a sustainable solution that can be achieved in a realistic form.

Stickdorn et al. (2018) defined six principles of service design including:

1. ***Human-centered:*** it takes into account the considerations and needs of all the people affected by the service.
2. ***Collaborative:*** stakeholders of different backgrounds and disciplines should be actively involved in the design process.
3. ***Iterative:*** service design is an iterative process that adapts and explores possibilities toward the final product.
4. ***Sequential:*** the service should be visualized and presented in a sequence of related actions.
5. ***Real:*** the needs of the user must be studied in reality, and the proposed prototyped ideas must be feasible and can be implemented in physical or digital form.
6. ***Holistic:*** the designed service should sustainably meet the needs of all the stakeholders involved in the use of the service.

In this research, both approaches were utilized equally by adopting aspects, activities, and elements from each of them. For example, both approaches are human centered, considering the needs and requirements of the users. The presented research considered the requirements from the primary target users, language instructors, as well as the needs of the secondary target users, students from Finnish language courses. However, the secondary target users were not actively involved in the design process and their needs were mostly brought by the language instructors. From the human-centered design approach, four of the phases explained above, were followed. However, the last phase, launch, was not reached. From the service design approach, the principles collaborative, real, and holistic were considered when language instructors were involved actively in the design process and the programming workshops designed aimed to be a solution for their needs. Nevertheless, both approaches consider iteration as an important step in order to have an ultimate design. In this research, the iteration process was not followed, mainly to time constraints, however, it would have been ideal in order to design and deliver a product that better respond to the educators needs.

3.1.2 Data Collection Methods

Diverse data collection methods were used throughout the different phases of the research. This list of methods includes both quantitative and qualitative methods.

- ***Questionnaires*:** three questionnaires (Roopa et al., 2012) combining close-ended questions and open-ended questions were used in this research, from which two of them collected qualitative data and the last one was both quantitative and qualitative data. The first questionnaire was a background questionnaire used during the user study that aimed to collect demographic information about the language instructors such as their group age, gender, as well as previous experience with social robots and with programming activities. The second qualitative questionnaire was a post-workshop questionnaire also used during the user study phase that aimed to collect information on participants' experiences during the co-design workshop, such as what was the most/least interesting part of the workshop, improvement tips, feelings regarding learning to program a social robot, and thoughts about incorporating it into their teaching activities.
  The third questionnaire used sought to collect both quantitative and qualitative data, the questionnaire was designed to be completed by students of Finnish courses after they have used NAO, which assessed their experiences and perceptions of the language learning robot. Six statements that could be answered on a scale of 1-8, being the first one strongly disagree and the last one strongly agree were presented. Some of the included statements were: "Practicing my speaking

skills with NAO was smooth", "NAO could understand what I said most of the time" and "The activities presented by NAO were suitable for my level of Finnish", among others. The questionnaire also included the *Robot Attitudes Scale (RAS)* developed by Broadbent et al. (2009), a measurement composed of 12 polarized categories which can be valued from one to eight where the language learning robot can be categorized, for instance, as unfriendly/friendly; fragile/strong; unreliable/reliable, and complicated/simple. Lastly, the questionnaire had an open space where students could freely comment about their experience using NAO.

- ***Audio-recording of the co-design workshop and focus group interview*:** the co-design workshop was audio-recorded to allow for verbatim transcripts of the discussion and analysis of the data to discover relevant findings from it. In addition, a final focus group semi-structured interview (Vaughn, 1996) was conducted and audio-recorded after the evaluation of the programming workshops was concluded. During the interview, university language instructors talked about their experiences during the programming workshops; the interview included themes such as programming workshops, co-design workshop, learning journal, and NAO in the classroom.
- ***Workshop-canvas*:** the main objective of the designed canvas (Ahtinen et al., 2023), utilized during the evaluation of the programming workshops was not to collect data, but instead serve as a learning platform where all the content was presented. However, this canvas had an open space where participants could include comments, where they wrote a few ideas to try out during the programming sessions. In addition, we utilized the space to write notes about important information to share with the language instructors and information collected from their answers.
- ***Observation and notes-taking*:** direct observation (Baker, 2006) was done during the evaluation of the programming workshops in both phases: implementation and testing. During implementation sessions, the notes were written after the session has concluded to avoid making participants uncomfortable. During the testing session, notes were written in an observation table after and during each interaction between the social robot and the students of Finnish courses.
- ***Learning journal*:** a learning journal, "*a mechanism to increase metacognition through students' awareness of their cognitive processes as well as their management of these processes*" (McCrindle et al., 1995, p. 6), was created and given to language instructors. It was designed to be completed after each workshop session, hence allowing language instructors to self-reflect on their learnings of that session. The journal included questions related to their learnings of the day, positive and challenging aspects, and what could have been done differently in the

session. It also included the non-verbal instrument to measure emotional responses, *Emocard*s (Desmet et al., 2001), where language instructors had to mark the emotional expression that represented how they felt during that session. Emocards consists of 16 cards depicting cartoon faces from eight women and eight men expressing emotions. The expressions cover the dimensions of pleasantness and arousal, and each of them shows a variation in the mentioned dimensions. Excited emotions represent the higher levels of arousal meanwhile calm emotions represent the lower ones. The pleasantness of emotion varies from very pleasant to very unpleasant, however, there are some expressions that are neither pleasant nor unpleasant.

3.1.3 Data Analysis Methods

To analyze the collected data, two methods were utilized. The first analysis method utilized is *affinity diagram* (Beyer et. al, 1998), also called affinity wall, which is an embodied and collaborative analysis method. To create an affinity diagram, all the collected data is separated into individual notes that cover only one aspect per note, and all notes are organized in a hierarchy form visualizing common issues, themes, and relations between the data. These individual notes are called affinity notes and are organized in a bottom-up process that does not start from pre-defined structures; in contrast, all individual notes are read aloud and placed in categories that they might belong to. As affinity diagram is a collaborative process, a note can be later moved to another category if it is agreed upon by the members involved in the construction of the diagram. After notes have been grouped, they are given a name that represents them and summarizes the content of the group. By reading and building the affinity diagram, a researcher not only learns about the key issues and themes resulting from the data but also can see and identify all the exact information that is linked to that specific topic.

The second analysis method employed is *content analysis* (Elo et al., 2008), which can be used both for quantitative and qualitative data, and it is used to classify words and phrases that share the same idea. This analysis allows researchers to make valid inferences from the data to prove knowledge and new insights. Content analysis is an analysis method that might be used in an inductive or deductive way. Deductive content analysis is used when the purpose of the study is to test a theory, in contrast, inductive analysis is conducted from specific to general information, hence particular data is analyzed and then combined into a larger group. Both processes, inductive and deductive analysis, involve three main phases: preparation, organizing, and reporting. For the scope of this thesis, the focus will be put on inductive analysis, where first, open coding of the data by notes and headings is done. Secondly, headings are collected into coding sheets, and categories are created from them. The third phase, reporting, presents grouped data which contains categories with related and similar information.

The affinity diagram method was utilized with the data obtained from the audio-recording, sticky notes, and post-workshop questionnaire of the user study and co-design workshop. On the other hand, content analysis was employed to analyze the data collected from the focus group interview, learning journal, observation notes, and students' questionnaire gathered during the user evaluation of the design.

3.2 Research Phases

The research process has been divided into five phases including literature review, user study, design of programming workshops, evaluation of the design, and design implications for programming workshops.

The first phase, *literature review* aimed to discover related work conducted previously that could be linked to the research topic, as well as find the research gap to make a valuable contribution to the current research. In addition, different research methods and approaches were studied to select the most appropriate ones for the thesis research. Even though this phase was the first one, it was also an ongoing phase that continued throughout the research.

The second phase, *user study*, was implemented in the form of a co-design workshop where we met with the users, in this case, university language instructors, to design together a series of programming workshops. In this phase, important information such as user needs and expectations was gathered. Additionally, language instructors gave valuable feedback related to what kind of activities they would like to learn to program, how they wanted the theoretical information to be presented, and different aspects that could make the programming workshops, motivational and encouraging experiences.

The third phase, *design of programming workshops*, aimed to first analyzed all the insights and learnings gathered from the literature review and the user study. Continuing, they were utilized to design the programming workshops, a series of hands-on workshops that seeks to provide educators the necessary knowledge to program robotic applications.

The fourth phase, the *evaluation of the design*, was the hands-on experience by language instructors where they participated in the programming workshops and actually learned to program robotic applications that could be used in their teaching activities of the Finnish language. In addition, this phase was useful to discover all the positive aspects that were related to the programming workshops, as well as the weak points of them and possible improvements that could be made to make them better learning experiences.

The fifth phase, *design implications for programming workshops*, aimed to use all the learnings acquired during the whole research process and create implications guidelines for designing and implementing encouraging programming robotic learning application workshops that could help future researchers to design for pleasant and satisfactory user experiences of educators while learning to program robotic applications.

A summary of the different tasks, methods, results, and schedules of each phase can be seen in *Table 1*.

Table 1. Research phases of the thesis

Phase	Tasks	Methods/ Tools	Results	Schedule
Phase 1 Literature review	• Find previous literature related to robot-assisted language learning and previous experiences of educational professionals programming robots. • Discover literature related to research approaches, data collection, and analysis methods. • Select relevant literature and use it to support the research.	• Skimming. • Scanning. • Highlighting. • Summaries.	• Research approaches. • Research methods. • Related work.	November 2022 - March 2023
Phase 2 User study: co-design workshop	• Discover initial needs and expectations from language instructors for programming workshops. • Explore potential activities that could be taught during programming workshops. • Discover preferred learning modes and factors that could be encouraging.	• Consent form. • Background questionnaire. • PowerPoint presentation. • Audio-recording. • Post-workshop questionnaire.	Qualitative data: • User's needs and expectations. • Design considerations.	January 2023
Phase 3 Design of a series of programming workshops	Planning, designing, and implementing a series of programming workshops considering the needs expressed by the educators and the insights from the literature reviewed.	• Elias Robot app. • Choregraphe. • Workshop-canvas.	Programming workshops structure.	December 2022 - February 2023
Phase 4 Evaluation	• Hands-on programming with language instructors. Evaluation of the design with real	• Consent form.	Qualitative data: • Strengths, weak points and needs	February 2023

of the design	users to get the benefits of the workshop and needs for improvement. • Testing the activities designed and observation with secondary target users (students). • Interviewing language instructors to discover their experiences during the programming workshops.	• Learning journal. • Students' questionnaire. • Observation and notes taking. • Focus group interview. • Audio-recording.	for improvements of the programming workshops. Quantitative data: • Students' perceptions of using a robot to learn languages.	
Phase 5 Design implications of programming workshops	Recover all the learnings and insights from the research process and create design guidelines that can be used in future research.	• Analyzing. • Highlighting. • Summaries.	Design guidelines for designing and implementing encouraging programming robotic learning application workshops for educators.	March 2023

3.3 Research Platforms

This section includes the three different technical platforms used during the master's thesis research including *NAO* robot, *Elias Robot app,* and *Choregraphe*.

3.3.1 NAO Robot

NAO robot, seen in *Figure 3*, is a bipedal social robot designed by Aldebaran, a part of United Robotics Group, which is an intelligent humanoid robot that can be programmed for different purposes. NAO has plenty of functionalities including speaking, recognizing speech, walking, reproducing sounds, and recognizing objects and people, among others. On its head, NAO has two sensors, two cameras, and four microphones. In addition, there are two speakers fitted on its sides (looking like NAO's ears); apart from the tactile, or touch, sensors on the top of its head. Two cameras are placed inside NAO's mouth and forehead, respectively. On its chest, there are four ultrasonic or sonar sensors, used to measure distances from walls, people, or objects. NAO counts with three tactile sensors installed in each of its hands and one pressure sensor in each of its feet (called bumpers). In total, NAO has seven touch sensors and 25 degrees of freedom that allow it to move around the environment as well as interact, recognize, and understand it (Anter et al., 2019).

Several ready-made programs are available online to be downloaded and used with NAO, however, NAO can also be programmed using other tools such as the software Choregraphe and the application Elias Robot.

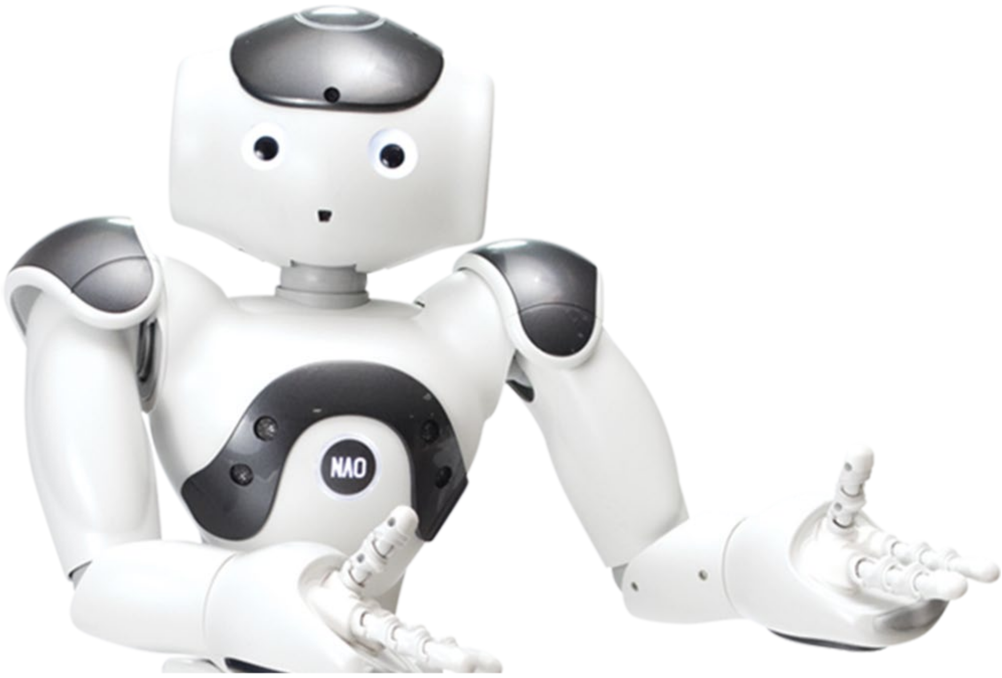

Figure 3. NAO robot (source: *https://www.aldebaran.com/en/NAO*)

3.3.2 Elias Robot App

Elias Robot is a language learning app that can be used with several social robots such as NAO V5, NAO6, and Pepper. While using the app, students can practice with Elias multiple languages by listening and speaking. Elias Robot was created by *Curious Technologies Ltd*, a Finnish company that develops voice user interface applications for educational purposes.

Several activities can be presented by Elias Robot related to topics such as colors, seasons, and emotions. In addition, teachers can use the lesson editor feature, seen in *Figure 4*, to modify the included activities or design new ones that respond to their teaching needs. Educators can create individual activities or a whole course, adding any of the five different exercise types, including *watch* where students can watch a video; *repeat* where a list of words can be presented by NAO and students need to repeat them after it; *remember* which presents the picture of the words mentioned above and the student has to name the object seen in it; *chat* where students can have a conversation with NAO regarding a specific topic; and *quiz* where NAO presents a picture or ask a question and student needs to answer. In addition, the created lessons can be easily shared with others to collaborate on the creation of robotic applications.

Elias Robot also gives positive feedback when correct answers are given by students, including dancing, cheering, and changing the color of its eyes. Furthermore, the Elias Robot app allows monitoring students' improvement as each exercise counts with a progress bar that indicates how accurately the student pronounces the expected word or phrase. Moreover, the student collects stars in each learning session which also serves as a motivation and gamification factor.

Some of the current features of the Elias Robot app are presenting the lesson that has been generated by the teacher, the student can freely choose which activity to complete based on the pre-selection of activities proposed by the educator. In addition, the student can chat with Elias about different topics, as well as engage in playful activities where the robot can dance, sing, and play the guitar for the student. Moreover, the student can write some text and ask Elias to say it, which is a useful feature if the student wants to know how a word or series of words are pronounced.

The Elias Robot application is constantly changing and at the end of this thesis project some modifications, which we did not utilize, have taken place. Currently, the lesson editor integrates a generative AI language model that creates vocabulary and conversations for the teacher. Additionally, a new feature is a chat based on an advanced language model that has been developed into NAO as a separate solution. With the AI-based chatbot, some improvements in the robot's ability to understand complex sentences have been observed, however, the robot still does not recognize intonation.

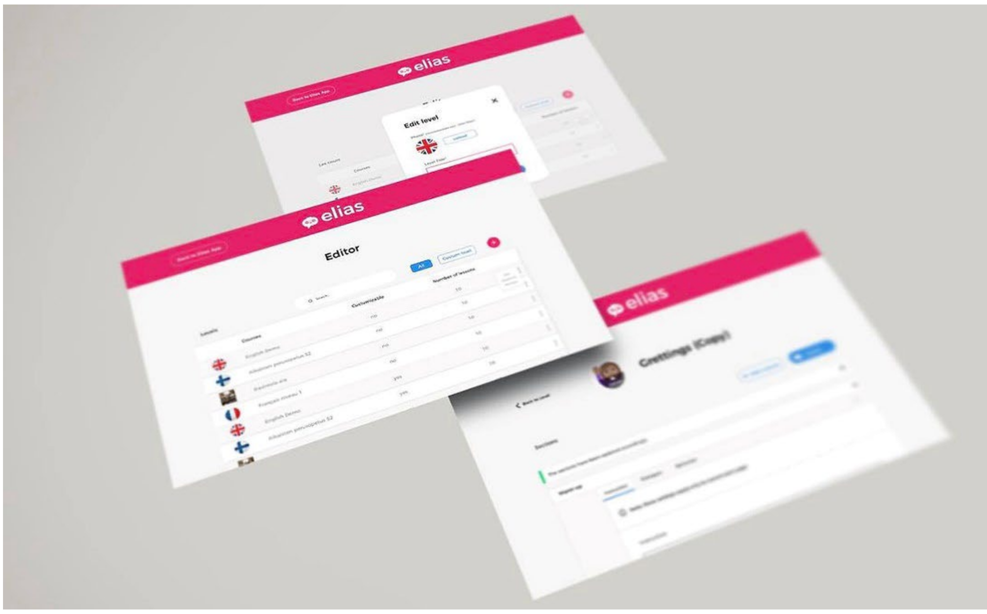

Figure 4. Elias Robot app lesson editor (source: *https://www.eliasrobot.com/lesson-editor*)

3.3.3 Choregraphe

Choregraphe, seen in *Figure 5*, is a programming platform with an intuitive graphical user interface based on visual-based programming that allows people without the knowledge of textual programming languages such as Python or C++ to program robotic applications in NAO robot and Pepper robot. Choregraphe can be used to create programs, write dialogs, set NAO's behaviors, change the language of the robot, and change the preferred camera to be used, among others; with visual programming languages which use drag and drop functionality to build a robotic application. Using this feature, the user can drag an icon (function or behavior) onto a workspace and drop it; in addition, the icon can be connected to another one to create a sequence of actions (Bravo et al., 2017). Miskam et al. (2014, p. 142) explained in their article how the environment looks:

"*The application window mainly focused on three main areas; box library that consist of the preprogram behaviors of the robot such as stand-up and sit down; working area that use for drop the box behavior from library and create algorithm; graphical representation of NAO able to execute the implemented behavior and able to connect with real robot in real-time motion.*"

Nowadays, a lot of robot programming software in educational robotics uses visual programming languages as it allows non-programmer users to program a robotic application without knowing the syntax and semantics of a programming language (Bravo et al., 2017). However, they require an understanding of some basics of programming and logical thinking such as, for example, how connections can be made and how loops work.

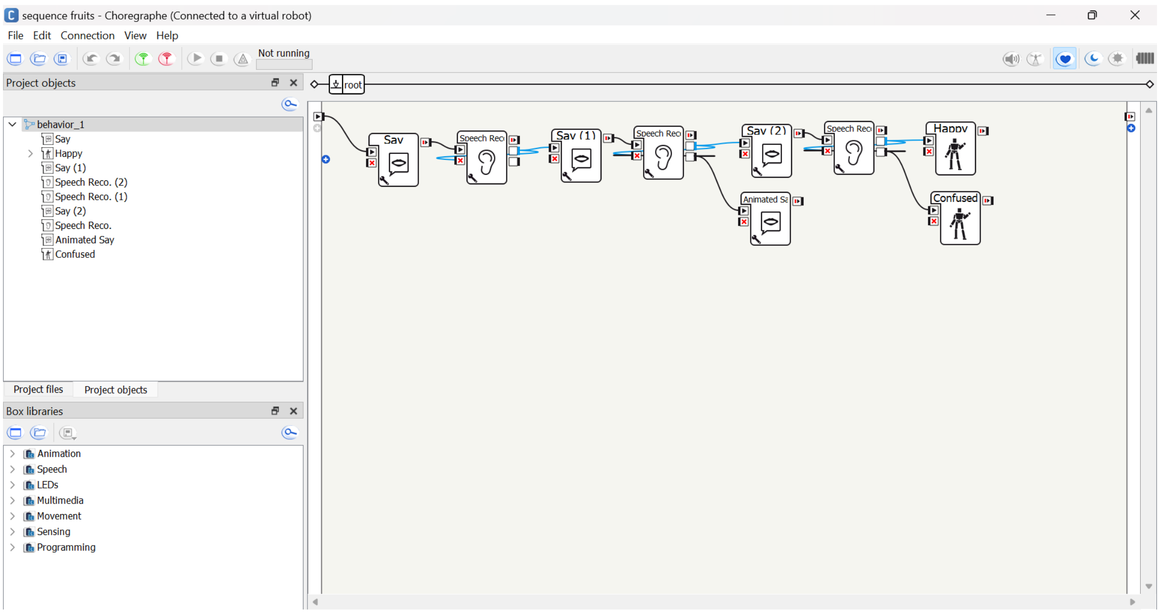

Figure 5. Choregraphe graphical user interface

4 User Study: Co-Design Workshop

The user study chapter describes the background information of the participants, data collection methods, data analysis methods, and overall findings. The user study named "*Learning the needs and expectations of language instructors to program a social robot for educational purposes*", was conducted in a co-design workshop form. This study contributed to understanding participants' needs and expectations regarding the programming workshops, as well as desired uses for NAO in their classrooms. The collected information was fundamental to design and implement programming workshops that responds to users' needs.

4.1 Objective of the Study

The objective of this co-design workshop was related to answer the **RQ1**: *What are the expectations and needs of university language instructors towards programming a social robot for teaching languages?*. In this study, it was expected to explore the robot's possibilities as well as the instructor's expectations and needs regarding using a social robot and programming it, in an educational environment. In addition, a co-design workshop method was selected, hoping to make language instructors participants and creators of their own learning experiences, allowing them to influence the content and teaching strategies used during the programming workshops.

4.2 Procedure

The co-design workshop was conducted in person in *Robostudio*, it involved one session of two hours in where we met with the language instructors to discuss and co-design the programming workshops. A PowerPoint presentation, seen in *Figure 6*, was created in order to guide the session, the agenda involved the following topics:

- ***Introductions and instruction*****:** each participant said their first name and something curious/fun/interesting about themselves. In addition, the main goal of the thesis project and the purpose of the co-design workshop were presented. Participants signed the consent to participate in advance, however, they were reminded that they were free to quit the workshop at any time and that it was going to be audio-recorded. Furthermore, anonymity when reporting the results was explained, and how the collected data was going to be stored. Participants were asked if they agree with those terms.
- ***Social robots:*** a definition of social robots by Gallagher (2007) was presented. The session continued with a brief presentation of all the robots that currently Robostudio has and what they have been used for.

- ***NAO robot:*** the social robot NAO was presented, and a series of concept videos of NAO doing different activities were shown. In addition, NAO did a small demonstration where it said hi to the participants, showed how the color of its eyes changed when their bumpers were pressed, sat, walked, and how it could have three different reactions when sensors placed in its head are touched.
- ***Elias Robot app:*** the functionality of the Elias Robot app was shown with a short *video* that showcased how Elias works and some children using Elias to learn vocabulary and chat with it. In addition, the lesson editor was presented where educators can create their own materials according to their needs.
- ***Brainstorming:*** the session continued with a brainstorming part, where a paper canvas and sticky notes were used in order to discuss and conceptualize for what activities NAO could be used for, the kind of activities the instructors would like to learn to program, if NAO would present the activities to individuals or a group of students; and if in a group setting, how many students would be part of each group. In addition, we discussed if the programming workshops should be done in small groups or individually, what were their expectations regarding the programming workshops, what kind of aspects would make them engaging and motivational workshops, how would they like the information to be presented, and finally their availability to participate of the programming workshops and the schedule for them.
- ***Closing remarks:*** when the session ended, the participant's contribution was acknowledged, in addition to the working team: Curious Technologies Ltd and Robostudio team.

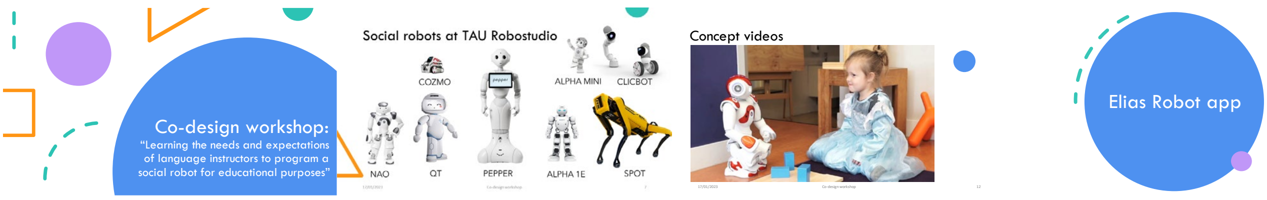

Figure 6. PowerPoint presentation used for co-design workshop

4.3 Participants and Ethical Considerations

Two participants took part in the co-design workshop. Participants were university instructors who belong to the Language Centre from the Faculty of Education and Culture of Tampere University and teach Finnish as a second language. A summary of their background information can be found in *Table 2*. In this research, the focus was put in the experiences over time of these two language instructors who took part in the complete workshop experiences, hence the participation of them was adequate in order to get rich contextual details of the experience (Barkhuizen, 2014).

Table 2. Participant's background information

Partici-pant	Group Age	Gender	Previous experience with social robots	Previous experience with programming	Interested in programming
P1	41 - 45 years old	Female	Tried communication with a social robot themself, and their students practiced Finnish with a social robot. The interaction was analyzed from the perspective of phonetics.	No	Yes, "*I am interested in what kind of new possibilities programming skills could provide to my work. I also like all kinds of challenges. Programming sounds difficult and complicated, but I know that it must be very logical, so I am positive that I am able to learn. And I am also very curious*."
P2	36 - 40 years old	Female	No	No	Maybe, "*I know nothing about it, so it is always interesting to learn something new*."

Participants agreed to participate in this study voluntarily and were free to quit it at any point without needing to explain the reasons why they were quitting. They signed a consent form in Microsoft Forms, seen in *Appendix 1*, in order to collaborate in this user study and agreed to have their voice recorded which was recorded with a cellphone and computer. Some ethical considerations were made during this study to take care of participants' privacy. In the consent form, a privacy notice was added where participants could read how their data was going to be collected and stored, as well as the purposes for collecting it. In addition, forms were downloaded from Microsoft Forms and all the information, including consent, background, questionnaire, and audio recordings was stored in secure Tampere University drives which require a password and multi-factor authentication to access the files and deleted from local devices. Furthermore, all the materials were pseudonymized and identifiable information such as personal names were removed from transcripts and citations. Finally, as the number of participants was limited, participants were asked how they wanted to be named during this thesis. They chose to be called "University instructors of Finnish as a second language from the Language Centre of Tampere University".

4.4 Data Collection Methods

To collect qualitative data during the co-design workshop, several methods were used:

- ***Questionnaire:*** participants completed a background, seen in *Appendix* 1, and a post-workshop questionnaire, seen in *Appendix 1*. The background questionnaire was asked in order to collect important information about the participants and the post-workshop questionnaire aimed to collect participants' experiences during the co-design workshop.
- ***Audio-recording:*** the whole co-design workshop was audio-recorded to make transcripts of the recording and be able to analyze the data thoroughly. As the workshop involved three people talking and discussing for two hours, recording the session was seen as the most appropriate approach.
- ***Paper canvas:*** during the brainstorming part of the workshop, sticky notes were used to complete a paper canvas that contained the questions related to this activity. Sticky notes were used by participants to write down their ideas and discuss between them if both agree on them. In addition, we also wrote down the ideas and comments that language instructors were saying in the moments where they just spoke, to not lose those ideas.

4.5 Data Analysis Methods

The affinity diagram method (Beyer et. al, 1998), was used for the thematic analysis of the quantitative data collected during the co-design workshop. Answers from the post-workshop questionnaire were transcribed and added as affinity notes using participants' codes. In addition, affinity notes were also formulated and coded with the data obtained from the precise transcription of the audio recording. Furthermore, the notes written on the sticky notes, during the co-design workshop, were transcribed and organized in the same diagram. The affinity notes were coded with "R" for the notes transcribed from the audio recording, with "SN" for the notes written on the sticky notes, and "PQ" for the notes taken from the post-workshop questionnaire, in addition to "P1" and "P2" that corresponds to participant 1 and participant 2 respectively.

The affinity diagram was built by us, we focused on information that was related to the scope of this research. The *diagram* built with the tool *Mural*, seen in *Appendix 2*, concluded with three main categories, 15 sub-categories, and 72 affinity notes.

4.6 Findings

Valuable findings were obtained from the co-design workshop resulting in three categories including Activities with NAO, Designing of programming workshops, and Experiences of co-design workshop. From the first category, *Activities with NAO*, three subcategories were found. The first subcategory, seen in Figure 7, was related to the usage of NAO where it was discovered that NAO could be used either individually or by a small group of two students who would take turns to interact with NAO. The second approach was considered the best as students would be able to help each other, but still, have enough room to interact with NAO; **P1:** "*because they can help each other, as we did. We both try to make him stand up*." The second subcategory, expectations, was related to what is expected to be achieved with NAO, where language instructors stated that they would like to use the robot as a support, companion, and alternative way to practice. They considered that NAO could be used by students to practice for their speaking test, as NAO is stricter regarding the expected pronunciation than instructors. They mentioned that students would need to be more careful with their pronunciation so that NAO would be able to understand them. They recognized that sometimes when practicing with other students' peers or even when the instructors, they tend to help each other too much, but with NAO they would need to make an extra effort to be more precise in their speaking; **P2:** "*Pronunciation, I know that there are some students who are already using this Siri phone to practice pronunciation, so it could be similar with NAO*." The last subcategory, concerns, involved some questions that language instructors had regarding the activities with NAO. Language instructors considered that activities should be simple, as the most important factor is to provide students with a positive experience and avoid frustrations; **P1:** "*Keep it simple enough because if something does not work with the students then it is frustrating and then they do not see the point*." In addition, they were concerned about how the robot's speech recognition works and if it would be able to understand an answer with slight differences such as "one orange" and "an orange". Additionally, they considered that activities had to be meaningful and have a context that allows students to actually learn from the interaction with the robot instead of just interacting with it for fun.

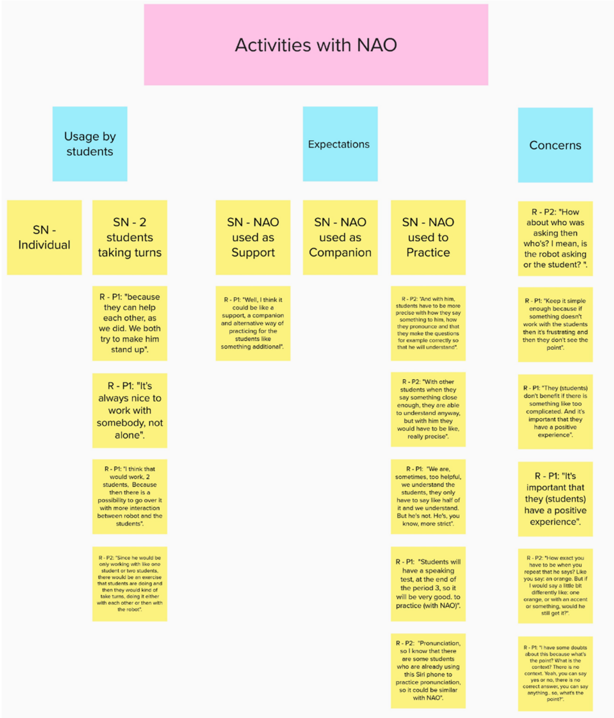

Figure 7. Affinity diagram category: Activities with NAO

The second category, *Designing of programming workshops* seen in *Figure 8*, resulted in five subcategories including expectations, engaging aspects, individual or group modality, activities to program, and schedule. The category expectations showcased that language instructors expected from the programming workshops to get the activities done, program activities, and make them work. Additionally, they expected more advanced instructions as they considered their general technology knowledge to be good and they did not need really simple step-by-step instructions. Finally, they would like the theoretical material and instructions to program the activities to be presented with text and screenshots of the main steps.

They stated that the programming workshops would be engaging experiences as far as they could try to program by themselves, seen as the most important aspect; test their ideas and see what is possible to do. They considered they had many ideas for the activities as well as the content available, and what was left was to try to program them; **P1:** "*We have the words, we have the ideas in the materials. We just have to find a way to how we can program it and how would it work*." They also thought that the best teaching approach for the programming workshops would be to work in small groups, as both language instructors had the same course material and the same objectives, hence they could work together to program the activities that then will be used individually in their classes.

The last two subcategories were related to the schedule of when the programming workshops was going to take place and the activities that language instructors would like to program. The schedule included three implementation sessions and five testing sessions on two campuses of Tampere University: City Centre and Hervanta. Activities brainstormed resulted in five topics: yes/no questions, verbs conjugated with "mina" (I) and "hän" (she/he), partitive cases ending in "ä/a" and "nen", repetition of a sequence of words, and object recognition. The presentation of some activities, like verbs and partitive, was thought to be done with the use of a picture that gave context to it.

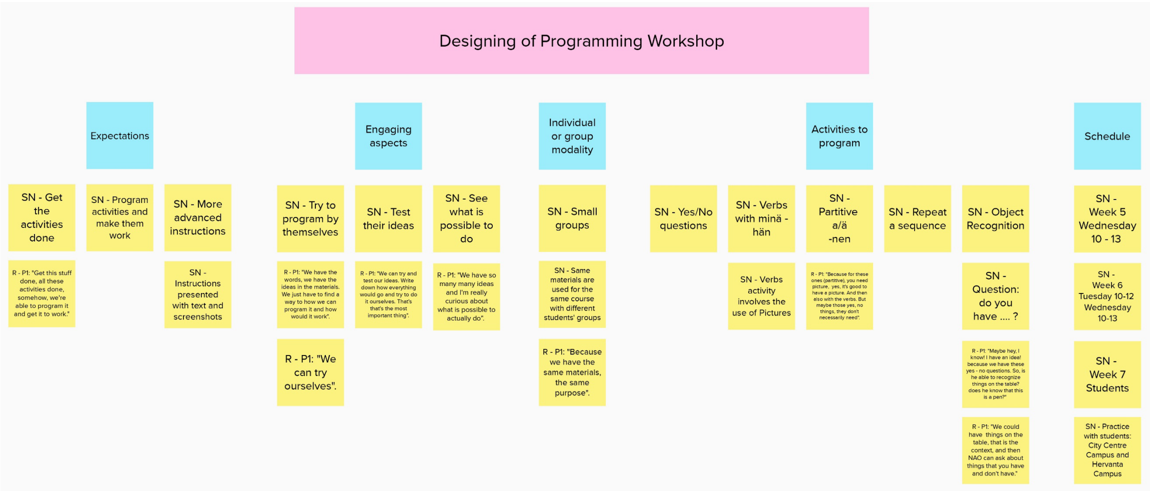

Figure 8. Affinity diagram category: Designing of programming workshops

The last category, *Experiences of co-design workshop* seen in *Figure 9*, gathered the feedback provided by language instructors after the session. They considered that the most interesting aspect of the co-design workshop were hearing about the different possibilities that robot offers for language learning and improvements that have been done after some years. They also mentioned that interesting aspects were seeing the robot in real-life as well as visualizing the programming interfaces and videos of the robot doing different actions; **P2:** "*It was very interesting to see the videos of the robot doing things. It is something I do not really see ever and I had no idea how well they work*." For future possible improvements, they indicated that the presentation of all the robots available at Robostudio could be shorter as the ultimate robot to be used was NAO and that they would have liked to see the Elias Robot app in practice; **P2:** "*I would have liked to see also the use of the Elias app a bit more in practice*."

Both believed that they could incorporate a social robot into their teaching activities, and they would use it in activities where the robot has something to provide to the student, to simulate real-life interactions, in activities where the surroundings play a role, and for activities where students can practice their vocabulary and pronunciation; **P1:** "*I would* *like to do activities where the robot has something to give to the student*." They stated that if a student can communicate with the robot effectively, the interaction will boost their confidence as it would happen when speaking with a native person. Finally, both of them said they were excited about working with the robot and that they were willing to participate in the programming workshops. Regarding their feelings related to learning to program a social robot, they said that they felt very excited and intrigued with the hope that they would come up with good ideas; **P2:** "*I feel intrigued and I hope we will come up with good ideas!*."

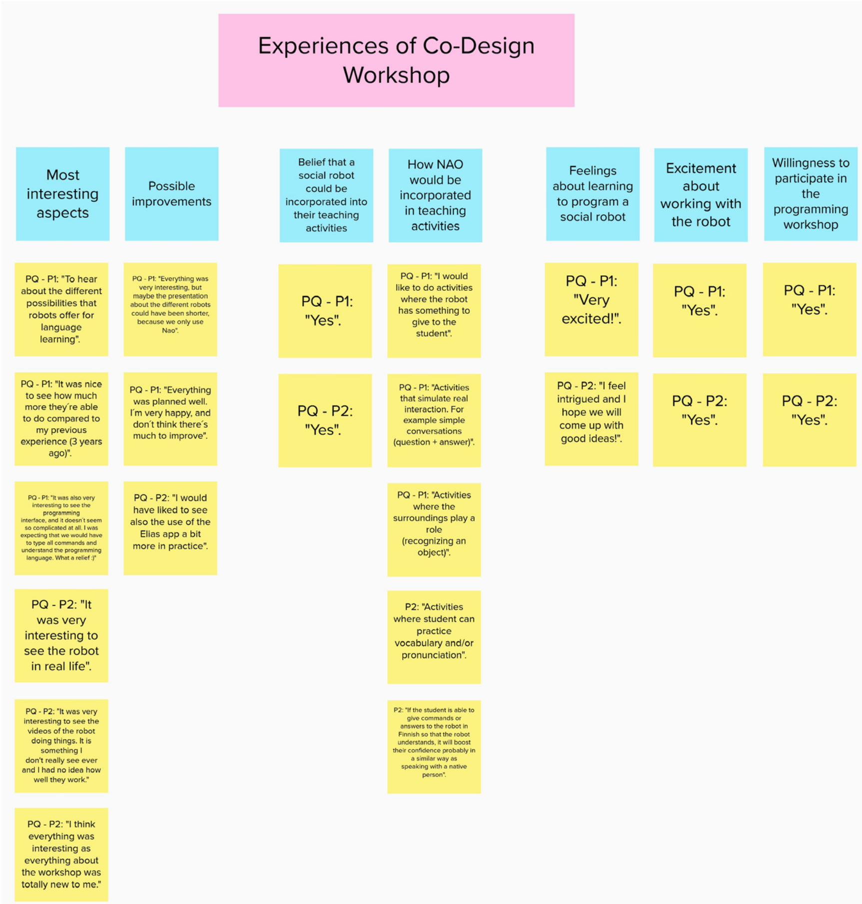

Figure 9. Affinity diagram category: Experiences of co-design workshop

4.7 Summary

The co-design workshop was a two hours session where we met with language instructors to co-design the programming workshops. The workshop also served as a user study to discover language instructors' needs and expectations from it. A summary of the main findings can be seen in *Table 3*. Overall, language instructors showed excitement to learn to program the NAO robot and to incorporate it into their teaching activities. However, they carefully considered how to involve NAO to design meaningful activities, with a real context, that help their students to practice their speaking skills. The most important aspect for them was to provide students with positive experiences and avoid frustration. To accomplish this, designed and programmed activities should be simple enough to be used by a pair of students at a time. Additionally, they considered that the programming workshops should also be conducted in small groups as they are teaching the same course, with the same teaching materials, and equal purposes, so collaboration within them in the implementation of the activities was seen as the logical and most productive way. They stated that engaging aspects of the programming workshops were to program by themselves, see the results of their implementations, as well as see what is actually possible to accomplish. In the future, they would like to incorporate a social robot into their teaching activities to simulate interactions with native speakers, and to provide opportunities where students could practice their speaking skills and knowledge of vocabulary, as far as the robot-student interaction provides the student a valuable learning experience.

Table 3. Summary of findings of co-design workshop

Category	Finding
Usage of NAO	By small groups of two students.
Expectations from NAO	Support, companion, to practice.
Concerns	Speech recognition, meaningful activities, simple activities, positive experiences for students.
Expectations from programming workshops	Get activities done. Program activities that work. Advanced instructions presented with text and screenshots.
Engaging aspects	Program by themselves, test their idea, see what is possible to do.
Teaching approach	Small groups who could collaborate.
Interesting aspects of co-design workshop	Possibilities offered by robots for language learning, robot improvements over the years, the robot itself and programming platforms.
Possible improvements of co-design workshop	Reduce available social robot's presentations and practical presentations of the programming platforms.
Incorporation of NAO in teaching activities	To simulate interactions with native speakers, where the robot can support students' learning and practice vocabulary and pronunciation.
Feelings about learning to program a social robot	Excitement and intrigue.

5 Design of the Programming Workshops

This chapter explains the different considerations and justifications for how the series of programming workshops "*Learning to use Elias app and Choregraphe for educational purposes*" were designed. The chapter also includes specifications of the programming workshops, their structure, and the content covered.

5.1 Design Features

The programming workshops were designed using the data obtained from the user study and the insights gained from the literature reviewed. Both sources of information were fundamental to design and implement hands-on programming workshops that responds to the needs of the users. For the programming workshops, the tool *Mural* was used to implement the workshop canvas which was used as a learning platform. The canvas contained all the contents expected to be covered during the series of workshops; additionally, it covered information related to the structure of the workshops, the goal of them, the pedagogical approach, and the requirements to complete them.

The *Mural-Canvas for the workshops* was divided into seven sections which are explained below, is it worth mentioning that pictures used to depict each section have been anonymized removing private and sensitive information as passwords.

- ***Introduction:*** this section included some welcoming words to the learning space.
- ***Description:*** the goal of the workshops and the pedagogical approaches followed, Paper's theory of Constructionism and Piaget's Constructivist, were explained. In addition, this section included information related to the content, requirements to complete the workshops, and their organization.

The introduction and description of the programming workshops sections can be seen in *Figure 10*.

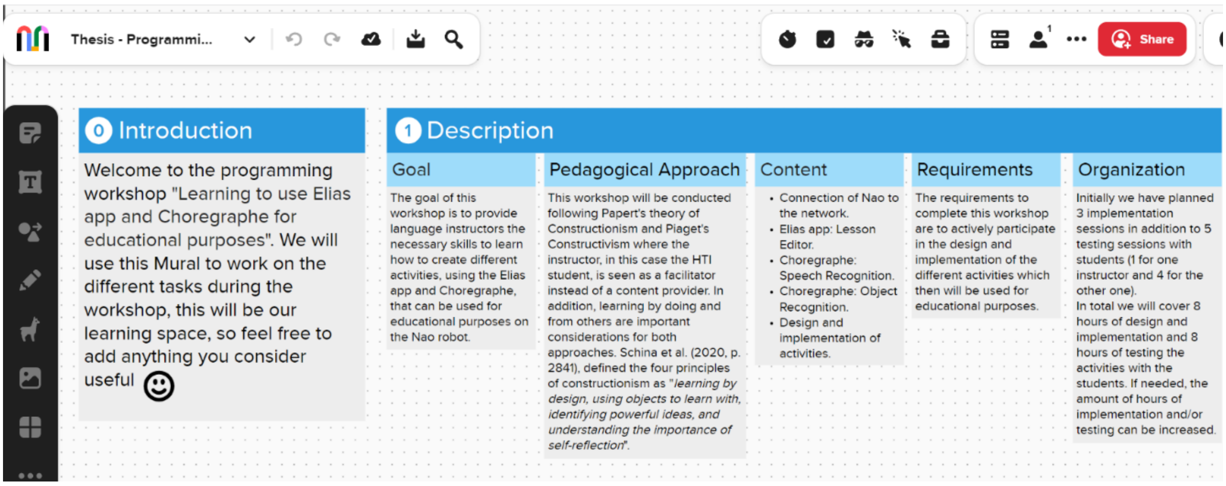

Figure 10. Introduction and description of the programming workshops

- ***Challenge #1:*** this challenge included instructions on how to connect NAO to the desired network.
- ***Challenge #2:*** was composed of screenshots from the Elias Robot app that show-cased how to connect NAO to the Elias app and, in addition, how to use the lesson editor and create different activities on it.

The challenge #1 and part of challenge #2 of the programming workshops can be seen in *Figure 11*.

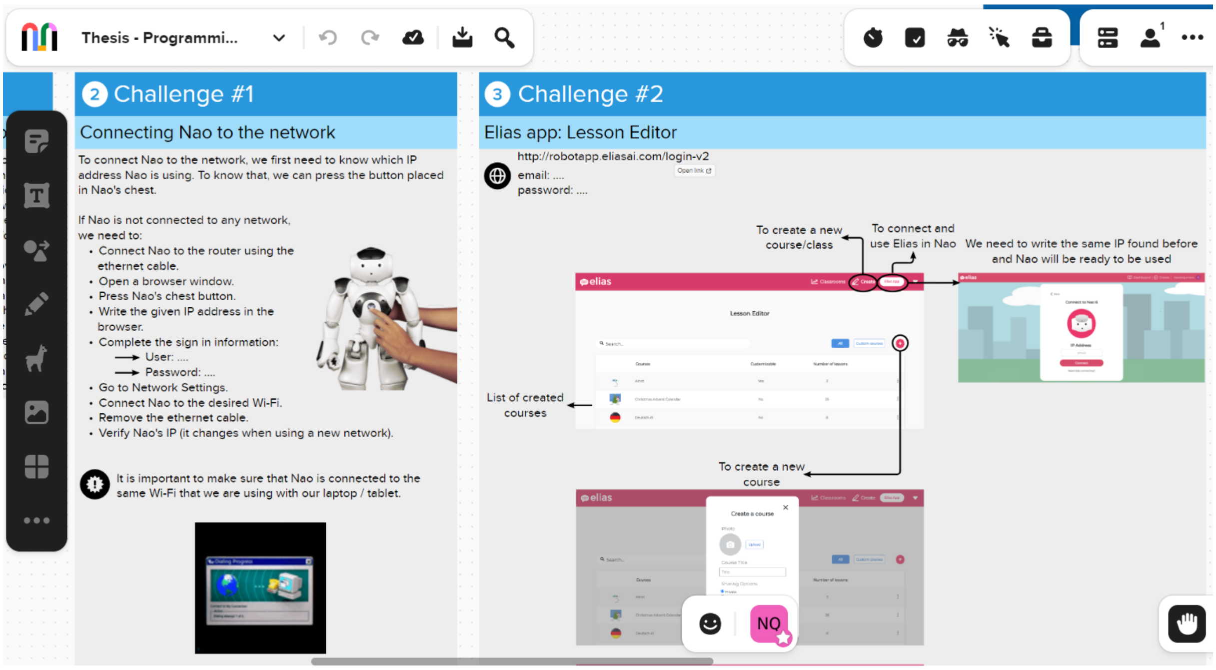

Figure 11. Challenge #1 and challenge #2 of the programming workshops

- ***Challenge #3:*** included screenshots of Choregraphe demonstrating how to create activities where NAO could recognize speech. There were two subsections in this challenge, Speech recognition between two or more words; and Speech recognition for a sequence of words.

Part of challenge #3 can be seen in *Figure 12*.

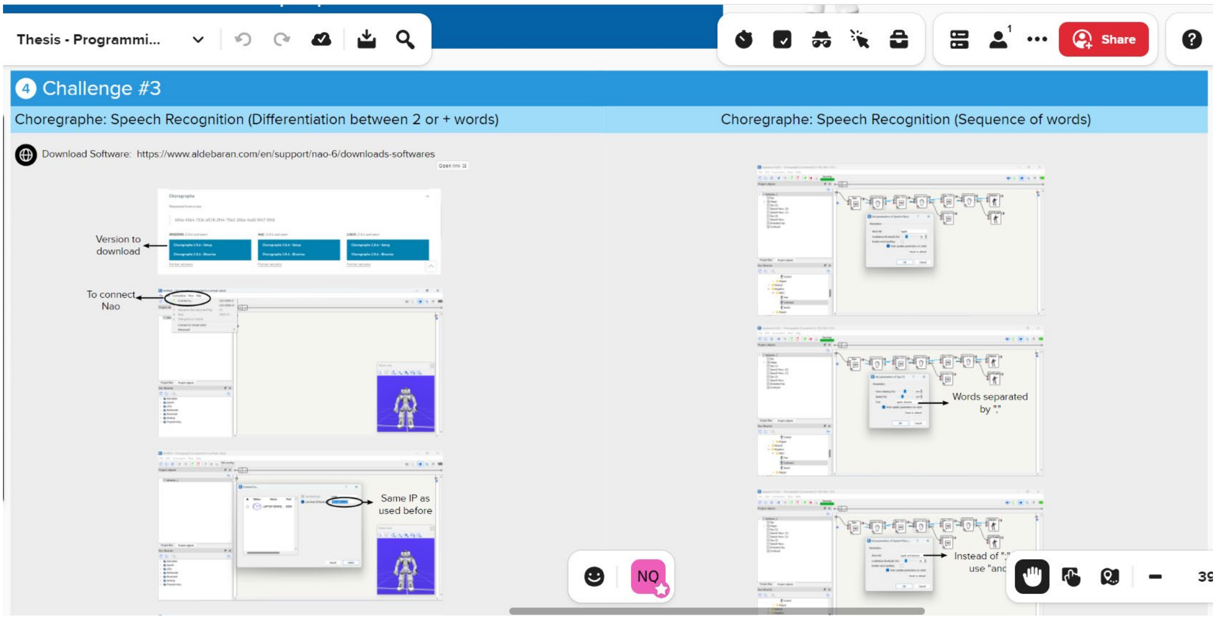

Figure 12. Challenge #3 of the programming workshops

- ***Challenge #4:*** was designed in order to create an activity where NAO could recognize objects; screenshots of Choregraphe were added representing the step-by-step explanation to implement the activity.
- ***Free space:*** this section was an open space where participants could add comments, ideas, reflections, and anything they desired.

Part of challenge #4 and the free space can be seen in *Figure 13*.

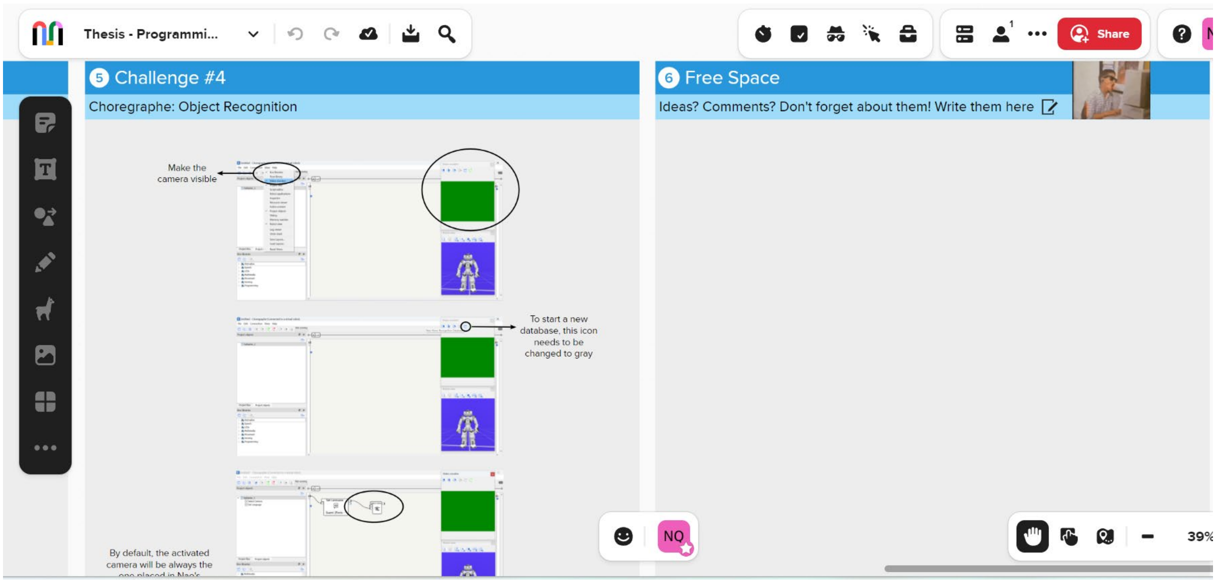

Figure 13. Challenge #4 and free space of the programming workshops

5.2 Design Justifications

As mentioned previously, the programming workshops were designed considering the input from the users during the user study and the insights from the literature reviewed.

Use of screenshots and advanced instructions. From the user study, some considerations made included the use of screenshots to depict the information and presenting more advanced instructions, as users consider they have enough technological knowledge, and did not need a really detailed step-by-step instructions. These considerations can be seen, for instance, in challenge #2 where not detailed instructions are given to use the Elias Robot app, as the software has a simple interface that is easy to use and self-explanatory when using it. On the contrary, Choregraphe's activities involved more explanation as they can be somehow more challenging.

Hands-on programming workshops. Another important factor for users, which they consider motivational and engaging, was to actually be able to implement the activities and see how their design ideas were put into practice. Taking this into account, the programming workshops were thought to be truly hands-on, requiring the participants to start implementing activities from the first session. It is important to mention that participants brainstormed about possible programming activities during the co-design workshop, hence the challenges presented were related to those possible design activities, and only relevant content for them was presented in the programming workshops.

Content influenced by users' needs and requirements. Related to the above element, the content was mostly influenced by users' expectations and requirements. Users wanted to use NAO with international students who were taking Finnish language courses. Students would practice with the robot for their speaking test; therefore, NAO could be used by small groups of two people, who would take turns interacting with it. In that sense, they wanted activities to be somehow more advanced, involving comprehension of a sentence, instead of a single word. However, they also considered that some context was still needed, so being able to add pictures to the questions was important. They initially thought to implement activities related to a) yes/no questions; b) verbs with minä (I) and hän (she/he); c) partitive ending with -a/ä and -nen; d) repeat a sequence of words; and e) objects recognition where NAO would ask: do you have …….? and students would need to show the correct object between a series of them. Considering those requirements, the content presented in the programming workshops was lesson editor of Elias Robot app, the creation of speech recognition activities in Choregraphe, and the creation of object recognition activities in the latter one.

Collaboration among participants to create the activities. One important insight learned from the user study also assented with the literature reviewed, is that for university language instructors, the collaboration between them was important. As both of them were teaching the same course with different groups, they wanted to work on the design and implementation of activities together, and they would then utilize them individually in their classrooms. Schina et al. (2020) did a review of publications that covered descriptions of teacher training programs in educational robotics made by several authors. Based on those, they were able to identify the best practices for training programs, and one of those is *collaboration*. The authors advised that participants should collaborate among themselves in a relaxed environment and, for example, develop together the final project needed to complete the training. Furthermore, utilizing the time of the training to create *teaching materials* was another best practice, hence training participants could do, for instance, a database of robotic activities. In the designed programming workshops, these best practices were incorporated, and university language instructors had to work together in the design and implementation of the activities which were going to be used later with students of Finnish courses.

Possibilities to practice and receive feedback and support. Two more best practices identified by Schina et al. (2020), are *practice* and *feedback and support*. Training participants should be able to practice as soon as possible their robotic knowledge and be involved in hands-on programming activities. In addition, the researcher or instructor should be present during and after the training program in order to provide support and, for example, participate in the participant's classrooms to observe how the different activities are carried out with the students. In the programming workshops implemented in this thesis, there were implementation sessions and testing sessions. We were present during the whole time supporting the design and implementation of robotic activities done by the university language instructors. In addition, we participated in the testing of the activities, with the students of the Finnish courses, providing technical support and helping the students to interact with the robot.

Workshop description information. Finally, Schina et al. (2020) did a series of recommendations that should be completed in any educational robotic teacher training, including a) setting requirements to complete the training program; b) a description of the training program which contains the total training hours, teaching practice hours, etc.; c) a teaching methodology based on a pedagogical theory; d) providing hands-on opportunities where training participants could put their knowledge into practice; and e) considering participants' needs and preferences to adapt the pace and the content of the training. All the suggestions made by the authors were considered when designing the programming workshops and can be seen, for example, in the description of them that includes the pedagogical approach followed, content covered, requirements to complete the workshops, and organization of them.

Pedagogical approaches selected. Furthermore, two pedagogical approaches were chosen to design and complete the programming workshops. One of them is Papert's theory of Constructionism (Papert, 1991) which implies that everything can be understood and learned by being constructed. Additionally, Andrews (2012) explained that each person mentally constructs the world by the experiences that they have had during their lives. According to Schina et al. (2020, p. 2841), Constructionism supports "*learning by design, using objects to learn with, identifying powerful ideas, and understanding the importance of self-reflection.*"

In addition, Piaget's Constructivism the second pedagogical chosen approach, focuses on learning with others who could be teachers, computers, robots, etc. Moreover, the teacher or instructor is seen as a facilitator instead of a content provider. Hein (1991) explained that in a constructivist environment the learners are able to build knowledge and learn both individually and socially. Constructivist states that the focus should be on the learner who should be interested in learning (instead of on the content to be taught) and that knowledge has always an attributed meaning given by the learner.

Both theories can be complemented as they consider collaboration among participants, learning with and from others, as well as the creation of new artifacts as important factors. Additionally, these theories recommend that the learning should be done in a real context, where learners have opportunities to learn by themselves with hands-on experiences, that allow them to give their own meaning to the content learned. The chosen approaches correspond with and support the designed programming workshops, where university instructors will collaboratively learn to program robotic learning applications by themselves, with practical activities facilitated by us.

6 Evaluation of the Design

The evaluation of the design chapter explains the aims of the study as well as how the programming workshops were evaluated. Detailed information about data collection and data analysis methods is included. Finally, the chapter ends with the main findings of the study and an overall summary.

6.1 Objective of the Study

The main objective of the study was to evaluate the design of the programming workshops, assessing if university language instructors could reach the goal of learning to design and implement by themselves, robotic activities which could be useful for their language courses. With the findings and learnings from users' experiences, weak points of the design as well as possible improvements could be identified for future work. In addition, the evaluation of the programming workshops aimed to answer **RQ2**: *What are the university language instructors' perceptions of the benefits and challenges of programming a social robot by themselves?*; and **RQ3**: *What are the university language instructors' experiences of the programming workshops?*.

6.2 Procedure

The programming workshops were conducted in person, they involved eight hours of implementation where university language instructors did hands-on activities by designing and implementing the robotic applications. In addition, they entailed eight hours of testing where the activities designed by the instructors, were tested with target students from their language courses.

The programming workshops were divided as follows:

- ***Implementation:*** One session of two hours and two sessions of three hours where we and language instructors met at Robostudio to go over the required learnings and implement the activities. In the first session, some initial instructions on how to connect NAO to the network and how to create activities in Elias' lesson editor were given, following the pictures presented on the canvas of the programming workshops. However, language instructors were able to start practicing the activities by themselves immediately. The second session also involved working with Elias editor to redefine the activities implemented in the previous session. During the third session, content related to Choregraphe was presented and some activities using the software were created.
- ***Testing:*** was carried out in five opportunities with different groups of students of Finnish language courses (one session belonged to one language instructor and

four sessions to the other language instructor) which were developed over two weeks, resulting in eight hours of testing. The testing was conducted in a classroom near the actual course classroom where students took turns in small groups of two people to interact with NAO. The testing was done in the explained set up to avoid background noise and allow students to interact with NAO freely without creating distractions for the rest of the group. We were present in the testing room acting as technical support and guiding the interaction between NAO and the students, while the language instructor remained in the main classroom with the rest of the students. In three opportunities, testing sessions were done with bigger groups of 20-25 students who could choose to participate in the testing. From those big groups, on average, ten students of each group participated in pairs interacting for approximately ten minutes with NAO and then completing the questionnaire. In the remaining sessions, the class was an optional one where students could go if they had questions or wanted some support on some specific topic; as groups were smaller, between 2-4 students, they were able to interact with NAO for a longer time of 20-30 minutes if they desired it.

6.3 Participants and Ethical Considerations

The participants of this study were the same participants described in section 4.3. In addition to them, 38 university students who were taking the language course Finnish I or Finnish II participated in the testing part of the study. Students completed an anonymous questionnaire about their experience learning languages with a robot and gave their written consent to be observed and to report the findings in this thesis. Three participants' answers were not included in the analysis hence one of them missed checking the consent statement of the questionnaire and two of them did not fully complete the questionnaire, resulting in 35 students' answers.

As previously, language instructors signed a consent form, seen in *Appendix 1*, to participate in the programming workshops giving consent to audio record the focus group interview as well as to report the findings of the group interview, programming workshops, learning journal, and classroom observation in the thesis. The consent form was downloaded from Microsoft Forms and stored in Tampere University drives which require a password and multi-factor authentication in order to access the files.

The audio recording was done with a cellphone and a computer, however, the files were deleted from the local devices and stored in secure Tampere University drives; together with learning journals, questionnaires, and observation notes. All the materials were pseudonymized and all identifiable information such as personal names was removed from transcripts and citations.

6.4 Data Collection Methods

During this study, several data collection methods were used, some of them were qualitative methods such as the focus group interview and note-taking, while the questionnaire completed by the students gathered both qualitative and quantitative data.

- ***Learning journal:*** was given to university language instructors to complete after each workshop session. The journal included questions related to their learnings of the day, positive and challenging aspects, and what could have been done differently in the session. It also included the method of Emocards where language instructors had to mark how they felt during that session. The template of the learning journal can be seen in *Appendix 3*.
- ***Observation and note-taking:*** during the programming workshops, we wrote our own learnings and observation notes after each session. In addition, we participated in the testing sessions observing the interaction between NAO and the students and taking notes about them using an observation table seen in *Appendix 5*.
- ***Questionnaire*:** students were asked to complete a questionnaire that assessed their experiences and perceptions of the language learning robot. Six statements that could be answered on a scale of 1-8, being one strongly disagree and eight strongly agree were presented. Some of the included statements were: "Practicing my speaking skills with NAO was smooth", "NAO could understand what I said most of the time", and "The activities presented by NAO were suitable for my level of Finnish", among others. The questionnaire also included the Robot Attitudes Scale (RAS); lastly, the questionnaire had an open space where students could freely comment about their experience using NAO. The questionnaire can be seen in *Appendix 6*.
- ***Focus group interview***: a 60-minute session was conducted with the university language instructors where they talked about their experiences related to the programming workshops, and we did open-ended questions related to themes including programming workshops, co-design workshop, learning journal, and NAO in the classroom. The session was audio-recorded in order to analyze the collected data thoroughly. The list of questions can be seen in *Appendix 4*.

6.5 Data Analysis Methods

The method of content analysis (Elo et al., 2008), was utilized to analyze both quantitative and qualitative data. Diagrams were created with the results of the quantitative data collected in students' questionnaire. In addition, the qualitative data included the information collected from language instructors' interview, language instructors' learning journal, observation notes, and students' feedback questionnaire.

6.6 Findings

In this section, the findings of the programming workshops are presented. The collected data has been divided into findings of quantitative data and findings of qualitative data.

6.6.1 Findings of Quantitative Data

A summary chart that contains all the findings related to students' level of agreement with statements can be seen in *Figure 14*. Students could value the statements from 1-8 where one was strongly disagree and eight was strongly agree.

The average answer from students of Finnish courses regarding the experience of practicing their speaking skills with NAO was 6.80. Students also considered that checking their knowledge of vocabulary with NAO was interesting giving this statement an average rate of 6.71. Similar values were stated to "In the future, I would like to continue using NAO to learn languages" receiving an average of 6.86 points. The higher rate given by students was to the statement related to activities presented by NAO being suitable for their level of Finnish, with an average rate of 7.26. On the contrary, the lowest values were given to the statements "Practicing my skills with NAO was smooth" and "NAO could understand what I said most of the time", receiving 4.77 points and the latter 4.49 points. These results show that the language learning robot had difficulties understanding how diverse people pronounced words, aspect influenced by accents, intonation, word stress, speech speed, and speech volume, among others.

Even though NAO had some challenges understanding what students replied, most of them still enjoyed the experience of using it, as can be seen in the following free comment by **S8:** "*I think it was really interesting to study and talk Finnish with NAO. Sometimes it does not understand exactly what I say but still it was fun.*" Moreover, for statements related to having fun with NAO while practicing their speaking skills (chosen by 16 students), activities presented by it according to their Finnish knowledge (by 18 students), and interest to use the robot in the future (by 15 students); the most selected value (mode) was 8, the highest value on the scale. On the contrary, the most selected value for "Practicing my speaking skills with NAO was smooth" was 4, a value under the neutral zone and closer to strongly disagree than to strongly agree, chosen by ten students.

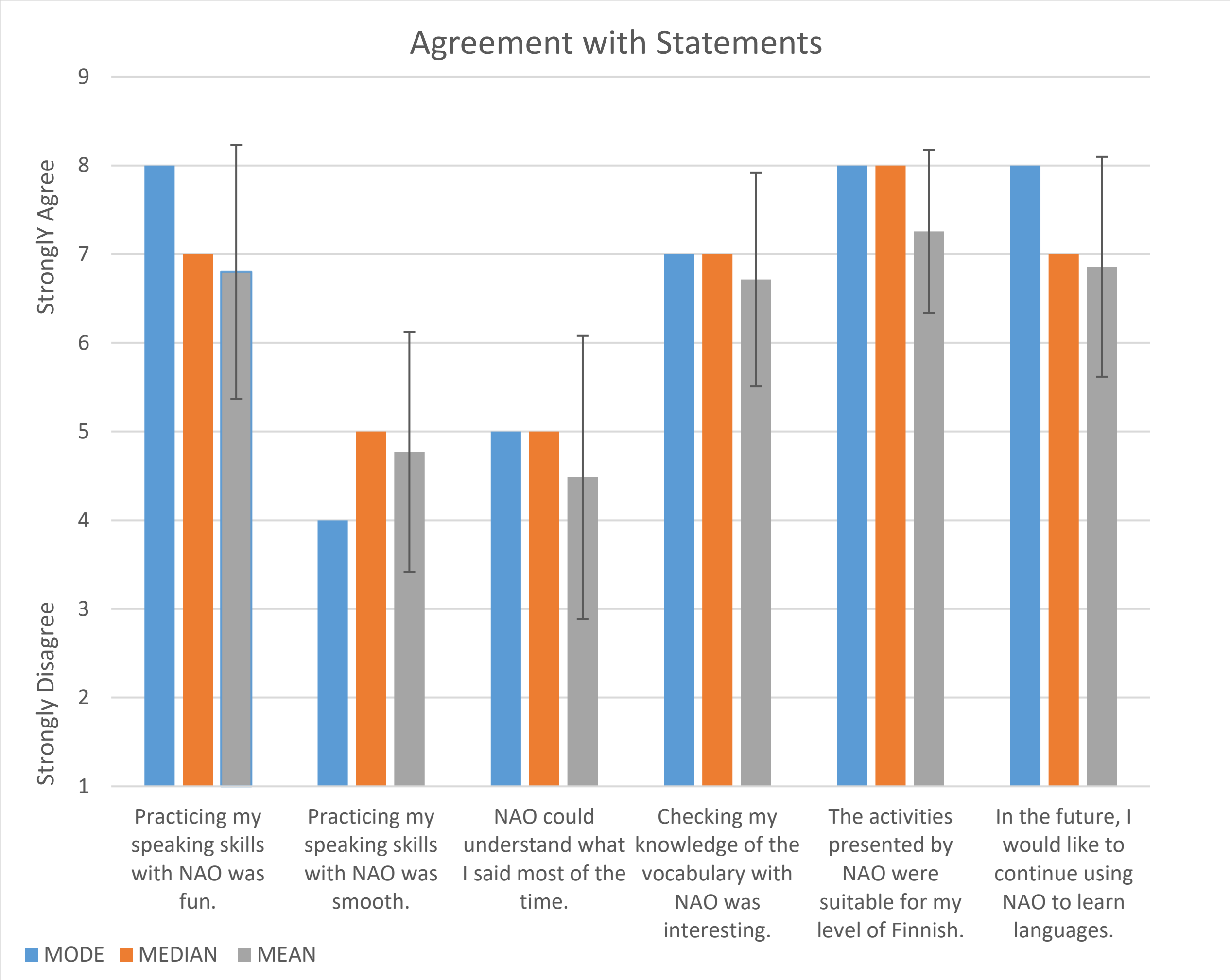

Figure 14. Students' agreement with statements given including mode, median, mean, and standard deviation (N=35)

The second scale utilized to evaluate students' perceptions of NAO was the Robot Attitudes Scale. A chart summarizing the findings of RAS can be seen in *Figure 15*. With this measurement, students were able to rate the language learning robot from one to eight in 11 categories. The value of one is closest to the negative perception while eight is concordant with the positive one. Between unfriendly/friendly, students rated NAO with an average value of 6.94 perceived closer to friendly than unfriendly. Similar rates were given to boring/interesting resulting in a 6.74 placing NAO closer to interesting; complicated/simple was rated at 6.77 considering the robot simple; and unhelpful/helpful was valued 6.63 contemplating NAO as a helpful robot. Additionally, NAO also was rated 6.40 for untrustworthy/trustworthy and 6.23 considering it useful instead of useless. Regarding NAO's usability, it was rated at 6.09 placing it closer to the end of easy-to-use than hard-to-use. The following categories were valued under 6 but still above 5; basic/advance was valued at 5.49, unreliable/reliable at 5.77, and fragile/strong at 5.89. Even though the rates were lower, they were still above the middle value of 4. Finally, the highest value was given to the category dangerous/safe where NAO was rated 7.54, defining NAO as a safe robot as the maximum possible value was eight.

Additionally, the most selected value (mode) for categories including untrustworthy/trustworthy, dangerous/safe, and complicated/simple; was the highest possible value, 8, defining NAO as trustworthy (by 11 students), safe (by 25 students), and simple (by 12 students). On the other hand, the minimum most selected values were 5 for the categories of fragile/strong (however this category also got mode value 7, making it impossible to represent in the chart, by eight students), and 6 for both basic/advance (by 15 students) and unhelpful/helpful (by 11 students). Even though the values are lower compared to the highest one, they are still good values which are above the medium value of 4.

A table summarizing the most selected values (mode) given in both scales (Agreement with Statements and RAS) can be seen in *Table 4*. The table has been organized from the most repeated statement/category to the least repeated one. If the statement/category has been repeated the same number of times, the second filter was the given value sorting them from the biggest to the smallest.

Table 4. Summary of most frequent values (mode) selected by students for level of agreement with statements and RAS.

Statement / Category	Frequency of repetitions in students' answers	Given Value
Dangerous/safe	25	8
The activities presented by NAO were suitable for my level of Finnish	18	8
Practicing my speaking skills with NAO was fun	16	8
In the future, I would like to continue using NAO to learn languages	15	8
Basic/advance	15	6
Complicated/simple	12	8
Untrustworthy/trustworthy	11	8
Unhelpful/helpful	11	6
Practicing my speaking skills with NAO was smooth	10	4
Fragile/strong	8	5

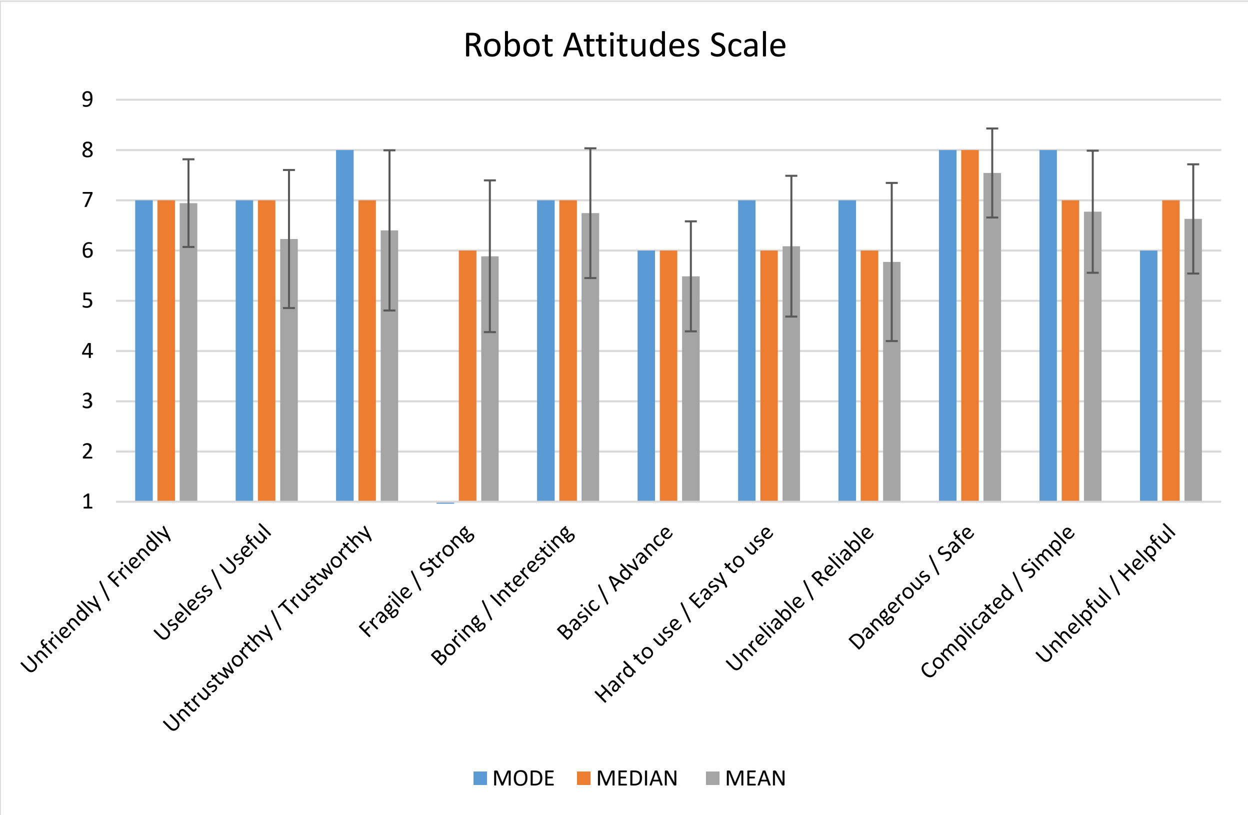

Figure 15. Students' answers to Robot Attitudes Scale including mode, median, mean, and standard deviation (N=35)

6.6.2 Findings of Qualitative Data

The findings of qualitative data collected from language instructors' interview, language instructors' learning journal, observation notes, and students' feedback questionnaire were analyzed and divided into a *table* containing 14 themes. A summary of these findings can be seen in *Table 5*.

Overall experiences of programming workshops. Language instructors considered that the workshops were well organized with clear objectives; in addition, they found the software utilized easy-to-use. They mentioned they like the fact that they were able to think of their own ideas regarding what activities to do with NAO and test them; **P1:** "*The software was easy-to-use, and we could use our own ideas. So I think we really got what we want it*." Even though participants were not expecting NAO to function perfectly, as one of them had previous experience with robots, they were happy about all the activities they were able to program and how consistently NAO worked. During session 1, participants learned to program NAO using Elias as well as to connect it to the network. During session 2, participants learned some tricks on how to improve NAO's intonation and considered the session a good revision of the Elias app. During session 3, participants learned to program NAO using Choregraphe as well as the pros and cons of Elias app and Choregraphe. Both participants mentioned that during session 1 they should have had a short and proper break. During sessions 2 and 3 they said everything went fine and that they had much fun. It was observed that during the three sessions, language instructors created eight activities, six using Elias and two using Choregraphe. The activities in Elias have been designed for the students of Finnish II therefore, they are slightly more advanced and require a greater understanding of the question on the part of the student. The activities were created using vocabulary related to hobbies, family members, and money with the quiz feature. On the other hand, the activities created with Choregraphe involved greetings and days of the week.

Benefits and positive aspects of programming workshops: implementation sessions. Regarding the benefits of the programming workshops, language instructors considered that one of them was knowing NAO's possibilities and limitations which are learned by the experience of programming. Another benefit was that the hands-on learning experiences were a fast and easy way to learn how to program. They compared them with other traditional learning methods and recognized that the programming workshops allowed them to learn better and in an efficient form as they could test all their implementations with NAO immediately; **P2:** "*The workshop, especially when compared to any other way, if I would have wanted to learn how to program him [NAO] and do something, it was so much faster. I am sure that if I would have like, I do not know, got some little materials for example and videos... This was so much better and so much easier when you get to try it yourself and you actually are doing it immediately. It helps so much. It was so fast to learn it*."

During session 1, participants considered it was good that Elias app was really easy and intuitive to use. They also liked the fact that they were able to test their activities and editions with NAO immediately after implementing to see how they worked. Additionally, they mentioned that a good aspect of the session was the cooperation between them. It was observed that participants prepared activities that had meaning (and were useful) for them. Mostly they did activities with questions that involved some comprehension of the vocabulary used, i.e., picture of a family with names asking if Maria has sisters, what is the name of her older brother, what is the name of her mom, etc. All the activities were created using Elias app with the quiz type of activity. They would like that students use NAO to practice activities and questions like the ones they were going to ask in the speaking test. They learned to use Elias app quickly and they took advantage of some offered possibilities as duplicating a lesson or using the pictures from the picture bank. P1 took the lead, however, both worked collaboratively, helping each other, sharing ideas, doing different parts of the job (one edited the picture while the other one wrote in Elias app), getting excited when things were working correctly, and laughing about robot's pronunciation. They continuously tested their ideas, and after each implementation, they checked with the robot how everything was working and looking. They really liked that the robot was able to generalize answers and recognize them using keywords, for example, if the answer was John, the robot was able to recognize: Minä olen John, Mä olen John, Mä oon John, Minum nimi on John, etc. (all different forms of saying: I am John / My name is John). The activities implemented were related to the topics: family members (three sets of seven questions), hobbies (one set of three questions), and how much (money vocabulary) (two sets of four questions).

During session 2, participants considered they were really productive, and by revising the implementations done during the previous session, they were able to improve them and have them ready to use. It was observed that they had the issue that they were not connected to the same network as NAO, (so they could not access Elias app in NAO) however, they recognized quite quickly that they needed to be in the same network. When starting, they said that they did not remember how to do things, nevertheless, they started completing the activities and modifying them really fast. Instructors paid a lot of attention to how words were pronounced. They went over sentences and pronunciation of NAO several times, they decided to remove the question mark on some sentences as the intonation of NAO sounded rare. They also checked how NAO pronounced names and how it recognized answers. They took one break after we proposed it. They said they were so focused on the process that they do not realize the time; and that it is fun, entertaining, and easy to create the activities. They were happy with the activities and how they were looking. They said they were so much better than before. P1 took the lead to create the activities, however, P2 was paying attention to everything that was happening and collaborating by editing the pictures, trying NAO, and checking its answers as well as thinking about names. They finished completing the activities in Elias app; **P1:** "*We were very productive. Reviewing the activities made last week was really important, and we were able to improve them a lot*." **P2:** "*We were able to finish some of the activities that we were creating with Elias. It was nice to get things done*!."

During session 3, they created two new activities using Choregraphe, which helped them to understand further possibilities with NAO. In addition, the incorporation of a visitor during that session helped them to discover some issues related to NAO speech recognition. It was observed that they understood how the activities can be programmed in Choregraphe quite fast. They took turns doing it, P2 was first and then P1. P1 said she needed hands-on experience in order to be able to understand properly how everything functions. They tried the activities several times and all the possible options to make sure that they worked correctly. They were able to create two activities with simpler vocabulary, greetings, and days of the week, a simple conversation with NAO. They liked the fact that for Elias, there is no need to be present controlling the activities, compared to Choregraphe. As they brought activities that were not planned before, we worked mostly as a team, thinking together about how to create them, and trying things out. Activities for Finnish I and Finnish II courses were created. P1 decided to make a list of vocabulary, so students from Finnish I can also try the activities in Elias. Activities from both Elias and Choregraphe can be used for students from Finnish II.

Benefits and positive aspects of programming workshops: testing sessions. During testing sessions, P1 mentioned that she was happy that students wanted to try NAO and was surprised about the number of students who wanted to do it. In addition, during testing session 3, students had a longer time to practice with NAO, an aspect that P1 considered beneficial. From the students' perspective, they defined the experience of using NAO as fun, good, interesting, and considered NAO as a useful technology. Additionally, they said that NAO worked well when simple language was used, and some students were willing to speak with NAO in the future; **S2:** "*It is a very good experience practicing with NAO. Fantastic job!*." **S6:** "*It worked pretty well with simple input speech, and I think it is very useful technology. Fun to use :)*." **S10:** "*It was a neat experience. I would like to do it again*."

Challenges of programming workshops: implementation sessions. Language instructors felt it was somehow frustrating when NAO was doing unexpected things and not behaving as expected. Additionally, one participant mentioned feeling overwhelmed by the number of functions shown in Choregraphe and thought that it would not be possible for them to learn all the content. Even though the software requires more logical thinking compared to Elias app, as understanding how the loops work, it ended up being a simpler process than expected. Additionally, the other participant stated that thinking about programming was felt like a challenge because in her mind, she was thinking about text-based programming. However, visual programming does not require complex text forms. Participants mentioned that the most challenging aspects of the implementation session 1 was understanding how to connect NAO, Elias, and the computer to the same network. Additionally, they realized that for speaking to NAO, the person should be positioned just in front of it and at a closer distance. It was observed that language instructors would have wanted to have a preview option in the Elias app instead of using the robot itself to try the activities. They got somehow frustrated when having to modify the language to Finnish for each created lesson. Initially, they wanted to do activities related to partitive, however, they discovered that the robot can not differentiate those minimum changes in pronunciation. They also wanted to use the type of activity dialogue, but the tool did not allow them to add a picture. Additionally, they wanted to modify the feedback provided by the robot when the option is not correct, but that was not possible. They had some challenges with the picture sizes; however, they resolved it quickly finding that the picture is seen properly when the shape is closer to a square. One own learning was to mark properly the breaks during the session instead of offering participants to take breaks when they desire it.

During session 2, P2 mentioned that Elias app started to feel familiar so no issues were present during that session. However, it was observed that the picture disappeared from the Elias editor after being placed, even though when using Elias app with the robot, the picture was there. It was also noticed that when the robot's feedback is not written, NAO shows the correct answer written as feedback.

Additionally, language instructors mentioned that during session 3, seeing Choregraphe interface felt somehow overwhelming but after trying it out, it was not as bad as expected. Participants did not have Choregraphe on their computers, due to needing a special request to download it. They used our computer to create the activities. It was observed that they got somehow frustrated when NAO was not working as expected and they have done everything as it should.

Challenges of programming workshops: testing sessions. P1 mentioned that during the first testing session between NAO and students, they heard that NAO had challenges understanding French accent. From the students' perspectives, they mostly highlighted the difficulties of NAO to understand what they said, other accents, and its difficulties in general regarding speech recognition. Additionally, they mentioned that sometimes NAO is misleading as it nods even though it is not able to understand what it heard; **S1:** "*NAO seems to have difficulties understanding other accents*." **S11:** "*You doubt whether doing it right or he just does not understand it*." **S15:** "*NAO could not understand some words that I pronounce*." In the future, students would like to use NAO for more complex back-and-forth communication where they could communicate with NAO in more than one-word answer. They also recognize the difficulties that imply programming a robot for different accents but said that once this problem is overcome, the technology would be great. Additionally, they mentioned the need for careful monitoring and responsible usage to be not "dangerous" or "biased" as it is sadly the reality of some current technologies; **S2**: "*It would be better to improve the answer other than specific answers. For example: How many laptops are? The answer is two but if I say, "two laptops" it can not understand*." **S17:** "*More dynamic conversation would be awesome*." **S18**: "*I would have liked more interaction, longer questions, or being able to ask the robot and learn from its answers*."

Learnings during programming workshops: testing sessions. During Session 1 (10.02), three students interacted with NAO (one from Finnish I, and two from Finnish II). The robot was placed on a table, so its microphone was at the same height as the students' mouth. The students interacted with NAO with much patience, eagerly, and happy when NAO understood them. They asked its name and appeared to feel a bit nervous, happy, and excited. NAO speech recognition did not work well with student of Finnish I but worked better with students of Finnish II. During Session 2 (13.02), ten students of Finnish II used NAO. Students' first reaction when seeing NAO was taking pictures, laughing, and looking at it. NAO seemed to understand better names than other words. It would have been nice to have more time for students to practice with NAO, as there were five pairs of students, and they were able to only to try two activities with NAO plus the questionnaire. NAO seemed to recognize better when a student answered with one word instead of a sentence. They interacted with it with a bit of shyness, happiness, and speaking to its ears. They used expressions as "here you go" and "voitko toistaa?" ("can you repeat?"). NAO speech recognition did not work always, it had some issues understanding other accents, but it worked fine in three situations and more or less in the other three. During Session 3 (13.02), 11 students from Finnish II used Nao. Their first reaction was to wave to it, and they were interested in how it was built. When interacting with it, some students only observed while others spoke to NAO's ears. After realizing NAO understood better when they spoke slowly, they did it that way. NAO speech recognition worked most of the time, however, hobbies' names were hard for NAO to understand. Students mentioned that it is confusing when NAO nods even when it does not understand them. During one test session, the picture in one exercise in Elias was not shown. During Session 4 (14.02), ten students of Finnish II used NAO. NAO sometimes lost its stability when moving. Students' first reaction was to ask its name and say it is so cute! Some students interacted with NAO with a bit of shyness while others were happy. Additionally, some students seemed frustrated when NAO was not understanding them while others were impressed by it. NAO speech recognition worked most of the time, nevertheless, NAO sometimes was a bit picky with pronunciation. Two incorrect answers were detected by NAO as correct (Roosa name and Uuno isan). Elias app skipped one question; the question was asked but the picture shown was the one related to a previous question (hobbies activity). In Elias app, the card did not flip back automatically when changing the questions. During Session 5 (17.02), one student of Finnish II interacted with NAO. The student took a selfie and asked us to record them while interacting with NAO. They interacted with NAO repeating patiently and seemed to be happy. NAO speech recognition worked well most of the time. NAO seemed to understand better after pressing the repeat button if not immediately answered after the question. The student from Finnish I who tried NAO in the first testing session, tried NAO again, and it worked correctly.

Aspects that helped to maintain motivation during programming workshops. Language instructors highlighted the possibility of testing their implementations immediately; as NAO was constantly present in the session, it was possible to see the progress done and their results with concrete implemented activities; which helped to maintain motivation. Another motivating aspect was to have a clear goal for learning to program and design activities. From the beginning, participants knew they were going to use the activities with the students of Finnish courses, and that real goal worked as motivation; **P2:** "*That we knew that we are actually going to use it for something. We are going to use it with students, because if we would have just been learning this and then we would not have those sessions with the students, it would not be as motivating because now we have like a very clear goal*." One of the participants mentioned that they felt challenged and motivated to learn new things and discover that they are actually able to do them. In addition, having a clear schedule of when activities were going to be used helped as a motivation and deadline to have everything ready; **P1:** "*Yeah, the schedule, we knew that the practicing sessions are coming soon. So we have to have everything ready*."

Duration of programming workshops. Language instructors considered that a 3-hour session was the most appropriate time to be able to focus on what they were doing without feeling they needed to rush to finish. In addition, they considered that the implementation time for the whole series of programming workshops was appropriate for the desired activities. However, significantly more time, for example, six sessions instead of three, would have allowed them to also learn other functions, for example, making NAO recognize objects.

Perceptions of workshop-canvas. Language instructors liked that the designed workshop canvas implemented in the Mural platform was really visual, with a nice design using pictures and some text, making it easy to perceive the complete content. It was observed that workshop canvas was almost not used, and maybe another tool as a physical notebook was more useful in this case. It was hard to look at the information displayed on workshop canvas and in Elias/Choregraphe at the same time, as only one screen was mainstreamed, and usually this was the one from the app/software. Even though the workshop canvas was not so much used during the programming workshops, language instructors considered it a valuable reference tool to check how to implement the activities in the future.

Relationship between the co-design workshop and programming workshops. Language instructors considered that the co-design workshop helped as inspiration, as with the concept videos they were able to see what was possible to do with NAO. They mentioned that without them, it would have been difficult to imagine what kind of activities are possible. After seeing these ideas, they were able to think about how activities could be implemented in order to fulfill their own teaching needs and cover the desired contents; **P2:** "*It gave us the frame and the base for everything. If we would have just really started programming, I think it would have been a lot more chaos and somehow we would not have had the understanding of the possibilities without it*." **P1:** "*Without it, we would* *have to make too much extra work like trying things. With it, we did not have to start from level zero, it was a good basis*."

Experiences with learning journal. The measuring method Emocards was not simple to understand at a glance, one participant did not understand how the faces were related to the emotions. The other one was able to understand it, but it took them some time to understand the logic behind it. Our own learning is that in the future, a tool like Emocards needs to be explained in detailed before using it. Language instructors found the learning journal as an efficient tool to reflect on their own learnings. They said that completing it only took between 5-10 minutes and it helped them to remember what they have done previously and also to see the concrete achievements reached in each session. During session 1, both participants selected that they felt excited pleasant in the Emocard. During session 2, P2 felt average pleasant, and during session 3 excited pleasant.

NAO in the classroom. Because NAO needs a quiet space to be able to understand what students say, it was chosen to do the interaction with NAO in a separate room, and language instructors were not able to observe. Even though they asked students how the experience was, their answers were most of the time polite. Only two students commented to one of the instructors that it was fun, but they needed to be really precise in their pronunciation and careful with the words chosen to respond, in order to get NAO to understand them. The same instructor mentioned that students seemed to be happy when they knew that NAO was going to be there and, additionally, that day every student was present in the class. To be able to observe student-robot interaction in the future, language instructors proposed that a) they could observe each other's classes, b) they would propose a separate practice session (however they are not sure if a lot of students would participate of it), or c) they could video record the session and watch the recording afterwards. Nevertheless, language instructors mentioned some positive aspects about the chosen setup such as that it was good that students were able to see NAO before interacting with it, to have a clear idea of what they were going to encounter later. In addition, they organized their classes in a way that students did not miss any important content that was given in the main classroom while interacting with NAO. Finally, as students tend to be just sitting during the 90-minute class, it can be tiring for them, so having the chance to go to another space to interact with NAO was seen as a positive break.

Difficulties in planning and implementing activities in NAO. Language instructors considered there were some difficulties at the beginning before knowing what can be done with NAO, but after knowing a bit, the ideas for the different activities were raised quite easily. Language instructors mentioned that it was easy to brainstorm activities as they both had the same purposes and clear objectives. They both wanted to use NAO to simulate interactions and conversations with real people, where interactions occur within a context; **P2:** "*And the fact that he is a robot, but he is a human, like he is a social robot.*

Well, he kind of gives like an example or a model of the situation, even though it is not the same, of course, he is still just the machine, but still, it gives kind of the illusion a little bit about having a conversation with the person. So why would we do flashcards that you never do with the person? So, we try to like create a conversation or something to simulate the real communication." **P1:** "*And with the context, because context really matters. Cause you never communicate without the context. So it has to be there*."

Use of NAO for teaching purposes. Language instructors thought that they could use NAO in the future with beginner students, where NAO could show something interesting as a flag or hat, and then students would need to ask NAO where it is from, what languages it speaks, and other introduction questions that are covered in Finnish I and Finnish II courses. However, language instructors considered that for more advanced students, using NAO would be hard as the possibilities in conversation are so versatile that it would not be possible to program NAO to respond to all of them. Both language instructors agreed that NAO could be used with students with special needs or students who need extra motivation, or a different teaching approach, compared to traditional ones. However, they mentioned that it can also be really frustrating for them when NAO is not able to understand what they say. Language instructors considered that is really interesting to think about for what activities NAO is useful and when it stops being. They said that they find it somehow like a paradox that while being in Finland, they offer students a robot to practice with instead of a real person. However, they mentioned that a robot is better than nothing and that they would use a robot for their teaching activities as long as there is some context and purpose for using it. They also mentioned that if they had a little amount of time, they would prefer to look for native people to talk with the students instead of programming speaking activities in NAO. It also concerned them how communication can be limited by the robot, due to its speech recognition capacities, and how that can affect students' speaking skills.

Table 5. Summary of main findings of qualitative data collected during evaluation of the design

Theme	Finding
Overall experience of programming work-shops	Organized, easy-to-use software, possibility to use their own ideas. Positive experiences regarding NAO's performance and progress done. Language instructors learned pros and cons of Elias app and Choregraphe, and how to connect NAO to the network. Eight created activities, six using Elias and two using Choregraphe. Activities created using vocabulary related to hobbies, family members and money with the quiz feature. The activities created with Choregraphe involved greetings and days of the week.

Benefits and positive aspects of programming workshops: implementation sessions	Knowing NAO's possibilities and limitations. Fast and easy learning experiences. Elias is easy and intuitive to use. Possibility to test immediately. Session 1 (01.02): Meaningful and useful activities created in a collaborative way. Activities involved comprehension of vocabulary. Students would use Nao to practice for their speaking test. Session 2 (07.02): Instructors paid a lot of attention to how words were pronounced. They were happy with the activities and how they were looking. They said they were so much better than before. Session 3 (08.02): Instructors understood how the activities can be programmed in Choregraphe quite fast. They took turns doing it. They tried the activities several times and all the possible options to make sure that they worked correctly. They liked the fact that for Elias, there is no need to be present controlling the activities, compared to Choregraphe.
Benefits and positive aspects of programming workshops: testing sessions	Many students wanted to try NAO. Students' perspective: positive experiences, fun, interesting, good.
Challenges of programming workshops: implementation sessions	NAO not responding as expected. Own fears about programming according to first impressions or previous knowledge. Connect NAO to the same network, NAO's speech recognition, and overwhelmed feeling by Choregraphe's first impression. Session 1 (01.02): Preview option was desired in the Elias app. Robot not able to recognize minimum changes in pronunciation. Not all the types of activities in Elias app allow to add a picture. Feedback provided by robot when option is not correct can not be modified. Session 2 (07.02): Picture disappeared from editor after being placed even though when using Elias app with the robot, the picture was there. It was also noticed that when robot's feedback is not written, NAO shows the correct answer as feedback. Session 3 (08.02): Participants did not have Choregraphe due to needing special permits. They got a bit frustrated when NAO was not working as expected and they have done everything as it should.
Challenges of programming workshops: testing sessions	NAO can not understand all accents. Students' perspective: NAO speech recognition and misleading actions. Possible improvements: improve speech recognition and possibilities of interaction.
Learnings during programming workshops: testing sessions	35 students from Finnish II and Finnish I interacted with NAO with a lot of patience, eagerly, speaking to its ears, and happy when NAO understood them. They asked its name and appeared to feel a bit nervous, happy, and excited. Students first reaction when seeing NAO was taking pictures, laughing, looking at it, waving to it, and they were interested in how it was built. NAO speech recognition did not work well at times and worked better at others. Some students seemed frustrated when NAO was not understanding them while others were impressed by it. NAO seemed to understand better names

	than other words. NAO seemed to recognize better when student answered with one word instead of a sentence. Students mentioned that it is confusing when NAO nods even when it does not understand them.
Aspects that helped to maintain motivation during sessions	Progress done was visible. Concrete and clear goals. Learn something new. Clear schedule.
Duration of the programming workshops	Appropriate session duration. Accurate duration of the whole workshop for established purposes.
Perceptions of workshop-canvas	Useful visual and novel tool. Useful as a theoretical reference. Workshop canvas was almost not used, as it was hard to look at the information on it and Elias/Choregraphe at the same time.
Relationship between co-design workshop and programming workshops	Co-design workshop was good for inspiration and working frame.
Experiences with learning journal	Emocards are difficult to understand. Learning journal considered a simple and efficient way to reflect on their own learning. Language instructors marked positive emotions during implementation sessions.
NAO in the classroom	Language instructors were not able to actually observe the interaction between NAO-students because of chosen setup. Positive aspects about the setup: seeing NAO before interaction, NAO used as a break, not missing important content.
Difficulties in planning and implementing activities in NAO	There were no major difficulties regarding planning activities to do with NAO. Language Instructors had concordant purposes.
Use of NAO for teaching purposes	In the future: with beginners students. For other teaching purposes: as with students with special needs. As far as there is a purpose and a context for using a robot

6.7 Summary

A series of programming workshops were conducted in person, they involved eight hours of implementation (divided into three sessions) where university language instructors did hands-on activities by designing and implementing robotic applications. In addition, they entailed eight hours of testing (divided into five sessions) where the activities designed by the instructors were tested with target students from their Finnish language courses. The data was collected through observation notes, learning journals, interview, and questionnaires; and analyzed into quantitative and qualitative data.

From the quantitative data, it was found that students rated the experience of practicing their speaking skills with NAO with 6.80 points (on a scale from one to eight). Students also considered that checking their knowledge of vocabulary with NAO was interesting giving this statement an average rate of 6.71. The higher rate given by students was to the statement related to activities presented by NAO being suitable for their level of Finnish with an average rate of 7.26. On the contrary, the lowest values were given to the statements “Practicing my skills with NAO was smooth” and “NAO could understand what I said most of the time”, receiving 4.77 points and the latter 4.49 points. On the scale RAS, students rated NAO (on a scale from one to eight) as friendly with an average value of 6.94, interesting with a value of 6.74, and simple rated 6.77 points. The lowest rates were given to the categories basic/advance where NAO was valued at 5.49, unreliable/reliable at 5.77, and fragile/strong at 5.89.

Regarding the findings obtained from the extensive qualitative data, during the interview sessions, language instructors highlighted that they were happy with the progress done as well as with the hands-on workshops, considering them a faster and easier learning experience compared to other learning opportunities. Some of the challenges encountered were related to NAO not responding as expected and own fears about programming according to first impressions of software or previous knowledge regarding text-based programming languages. It was important to discover some aspects that helped them to maintain motivation during the programming sessions, such as having concrete and clear goals, being able to observe the progress done, learning something unknown, as well as having a clear schedule. Additionally, language instructors considered the co-design workshop as an important inspiration session and a basis, in order to design their own activities that fulfill their objectives and covered the desired concepts. Concerning that matter, language instructors considered it was easy to plan activities as they have concordat purposes and they wanted to use NAO to simulate interactions and conversations with real people, where interactions occur within a context. In the future, they would like to use NAO with beginner students if the activities presented are meaningful for them, however, they found it difficult to think how NAO could be used with more advanced learners. Moreover, they expressed their concern on how NAO could influence students’ speaking skills as the robot’s speech recognition still needs further development, and currently, it can not recognize students’ accents, the stress of words, or different intonations.

7 Implications for Designing Programming Workshops

This chapter explains a set of 12 different implications that could be considered by future researchers to design and implement encouraging programming robotic learning application workshops for educators. The design implications numbered five to ten have been described to some extent previously by Schina et al. (2021). The previous implications have been extended with our learnings during the thesis project; moreover, those learnings allowed us to define the remaining set of implications.

1. ***Conduct a co-design workshop***
   It is important to conduct a co-design workshop to design the programming workshops with the educators involved and all the possible stakeholders that could participate in it. During this workshop, some basic concepts related to robotics applications could be explained in addition to discussing the educators' expectations and goals of the robot. Additionally, the co-design workshop would work as an interdisciplinary process where participants would be actively engaged and collaborate in the design of the programming workshops. Some design considerations, for example, learning modalities could be discussed, as each person has different preferences and information can be presented in several formats. Additionally, it has been found important to adapt the pace and content of the training content to participants' needs and preferences. The co-design workshop could be also useful to present concept ideas and initiate with educators brainstorming work related to possible usages of the robot as well as what kind of activities could be implemented with it. Finally, the co-design workshop could help to organize the schedule for the workshops.

2. ***Encourage educators to use their own ideas***
   Even though it is important to present concept ideas to showcase what could be done with the robot, those ideas should be used only as inspiration. Educators should be encouraged to then think by themselves about what activities can be accomplished with the robot and the programming workshops should be designed considering those.

3. ***Establish clear and concrete objectives for the participants***
   Ideating how the robotic applications could be used inside the classroom, for what purposes, and what objectives are a key factor in order to create useful and meaningful activities. Participants of the workshops should learn content that is truly useful for them, and which can be used to cover some teaching objectives and teaching concepts.

4. ***Create a clear and authentic schedule***
   When creating programming workshops, it is important to consider an authentic schedule that contains all the different phases of the programming workshops, for instance, implementation and testing sessions. Additionally, enough time for implementation and revision of the activities should be considered apart from the required time to cover all the theoretical materials. Having a clear schedule will help to have organized programming workshops as well as to serve as a motivation, as educators will have a target date when the implemented activities will be used.

5. ***Generate hands-on and collaborative opportunities that have a purpose***
   The workshops should be hands-on and collaborative opportunities where participants could work together to first design the type of activities that they would like to do, and second implement them. Participants should be able to participate in a collaborative environment, helping, and learning with and from each other, in order to have a positive learning experience.

6. ***Include descriptive information***
   When designing programming workshops is important to include a workshop description that contains a) requirements to complete the training program; b) description of total training hours, teaching practice hours, etc.; c) a teaching methodology based on a pedagogical theory; and d) organization of the workshops.

7. ***Create theoretical resources***
   Even though a facilitator must be present during the programming workshops to guide the learning process, it is also key to provide participants with theoretical resources that could be accessed in the future when the programming workshops have concluded, and they desire to create new robotic applications.

8. ***Allow participants to put their own learnings into practice early on***
   Participants should be able to start putting into practice their programming learnings from the beginning, as hands-on experiences allow them to have deeper and long-lasting learnings. Additionally, proving opportunities where participants can try by themselves will serve as an encouraging factor to stay motivated throughout the sessions.

9. ***Produce teaching materials***
   The workshops should be used as a space where educators can create their own teaching materials. Apart from learning the theory, participants could use the workshop

time to create meaningful activities that would then be used during their teaching classes with their target students.

10. Provide constant feedback and support

The programming workshops should include the participation of one/several facilitators who can ease the teaching of the theoretical materials as well as support the learning of the participants. The facilitator should be present to help the educators when needed as well as to learn with them during the workshop process. Additionally, the facilitator should be available to participate during educators' classes in order to provide technical support and learn by observation when robotic applications are used with the students. However, it is advised that educators should be able to find a way to participate and observe the interaction between robot-students in real-time.

11. Establish agreed breaks

Creating robotic applications can be a really fun and engaging activity where time can go by really fast. In order to avoid fatigue, it is advised that breaks are agreed upon by participants at the start of each session. The number of breaks should be concordant with the duration of the session and the facilitator should be responsible to control the time and propose the break at the agreed time.

12. *Have robots available*

Having the robot available during each workshop session will help participants to test their robotic applications fast, learn what works and what can be improved, and make the necessary changes immediately, instead of using time for first implementing and then testing in a different session. Additionally, educators will be able to use the acquired knowledge when creating the following activities.

8 Discussion

This chapter covers the summary of the key findings from the user study and user evaluation done and the answers to the research questions. Additionally, the limitations of this research are presented.

8.1 Summary of Findings

During the thesis research, two studies which provided key findings were conducted. The first one, a user study conducted in a form of a co-design workshop, involved the participation of two language instructors from the Language Centre of Tampere University. During the co-design workshop, language instructors showed excitement to learn to program NAO robot and to incorporate it into their teaching activities. During the brainstorming part, they carefully considered how to involve NAO in order to provide meaningful activities, with a real context, that help their students to practice their speaking skills. They considered that the most important aspect was to provide students with positive experiences and avoid frustration. To achieve this, the designed and programmed activities should be simple enough to be used by a pair of students at a time. Additionally, they considered that the programming workshops should be conducted in small groups as they were teaching the same course, with the same teaching materials, and with equal purposes. They thought that the best way to present the theoretical information was by screenshots and text. In addition, they mentioned that some engaging aspects of the programming workshops could be to program by themselves, see the results of their implementations, as well as to see what is actually possible to accomplish. In the future, they would like to incorporate a social robot into their teaching activities to simulate interactions with native speakers, and to provide opportunities where students could practice their speaking skills and knowledge of vocabulary, as far as the robot-student interaction provides the student with a valuable learning experience.

In the second study, a user evaluation of the designed programming workshops, the two educators learned to program the social robot NAO to incorporate it during their teaching activities. Instructors learned to program NAO using Elias app and Choregraphe and they designed activities that were evaluated by 35 students of Finnish Courses. Participants highlighted that they were happy with the progress done as well as with the hands-on workshop, considering them a faster and easier learning experience compared to other learning opportunities. Although they enjoyed the experience, they also mentioned some challenges as when NAO was not responding as expected, and their own fears regarding programming according to first impressions of software or previous knowledge of text-based programming languages. For language instructors, having concrete and clear goal, observing the progress done, learning something new, as well as having a clear schedule, were aspects that helped to main motivation during programming workshops. Language instructors considered the co-design workshop as an important session that helped them to find inspiration and was a basis to design their own activities that fulfill their objectives and covered the desired concepts. Additionally, they stated it was easy to plan activities as they have concordant purposes, both of them wanted to use NAO to simulate interactions and conversations with real people, where interactions occur within a context. In the future, they would like to use NAO with beginner students if the activities presented are meaningful for them. However, they also expressed their concerns on how NAO could influence students' speaking skills as the robot's speech recognition still needs further development, and currently, it can not recognize students' accents, the stress of words, or different intonations.

In addition, to language instructors, students from Finnish I and II courses also gave their perspectives. They rated the experience of practicing their speaking skills with NAO with 6.80 points (on a scale from one to eight). Students also considered that checking their knowledge of vocabulary with NAO was interesting giving this statement an average rate of 6.71. The higher rate given by students was to the statement related to activities presented by NAO being suitable for their level of Finnish, with an average rate of 7.26. On the contrary, the lowest values were given to the statements "Practicing my skills with NAO was smooth" and "NAO could understand what I said most of the time", receiving 4.77 points and the latter 4.49 points. On the RAS scale, students rated NAO as friendly with an average value of 6.94, interesting with a value of 6.74, and simple rated 6.77 points. The lowest rates were given to the categories basic/advance where NAO was valued at 5.49, unreliable/reliable at 5.77, and fragile/strong at 5.89. Additionally, students defined the experience of using NAO as fun, good, interesting, and considered NAO as a useful technology. Additionally, they said that NAO worked well when simple language was used, and some students were willing to speak with NAO in the future. Mostly, students highlighted the difficulties of NAO to understand what they said, other accents, and its difficulties in general regarding its speech recognition. Additionally, they mentioned that sometimes NAO is misleading as it nods even though it is not able to understand what it heard. In the future, students would like to use NAO for more complex back-and-forth communication where they could communicate with NAO in more than one-word answer. They also recognize the difficulties that imply programming a robot for different accents but said that once this problem is overcome, the technology would be great. Additionally, they mentioned the need for careful monitoring and responsible usage to be not "dangerous" or "biased", as it is sadly the reality of some current technologies.

8.2 Discussion

The co-design workshop aimed to respond to **RQ1**: *What are the expectations and needs of university language instructors towards programming a social robot for teaching languages?*. With the obtained findings, it is possible to say that the expectations and needs of language instructors were to program a social robot that can be used to simulate real-life conversations with native speakers following the communicative language teaching method (Savignon, 1987). Additionally, language instructors expected to create simple activities that allow a pair of students to interact with the robot at a time, providing them with positive learning experiences. This group setup has also been found beneficial in previous studies conducted by Engwall & Lopes (2022). Finally, language instructors desired that the programming workshops would be developed in small groups, as language instructors taught the same Finnish course, hence their purposes were equal, and working in a collaborative way was seen as the most productive and reasonable solution. Conducting a co-design workshop was really important in order to collaborate and design a series of programming workshops and adequate them to fit educators' needs and expectations. It also helped to restrain the extensive programming content and accommodate it to cover the future instructors' usage of the social robot for teaching purposes. In the review of 38 publications by Schina et al. (2020), there is no documented information, to the best of our knowledge, that educators were participants and co-designers of their own learning experiences. Hence, utilizing a collaborative design process where educators could influence and decide what, how, and when they wanted to learn, provides novelty to this research process.

The evaluation of the programming workshops aimed to answer **RQ2** and **RQ3**. Regarding **RQ2:** *What are the university language instructors' perceptions of the benefits and challenges of programming a social robot by themselves?*, language instructors defined that the benefits were that they could know NAO's possibilities and limitations by experiencing them by themselves. Additionally, they considered that the hands-on workshop was a faster and easier learning experience compared to other learning methods. One benefit was to have the robot available, so they could test all their implementations with NAO immediately and observe what worked well and what needed to be modified. All these benefits confirm the best practices defined by Schina et al. (2020) as practice and feedback and support. On the other hand, the challenges of the programming workshops were present when NAO was not working as expected, also seen in Ahtinen & Kaipainen (2020). In addition, one challenge which was overcome quickly was their own fears about programming according to first impressions or previous knowledge. Language instructors felt it was a challenge when they heard they were going to program, as their previous knowledge was related to programs using text-based languages and not visual-based languages. In addition, participants felt overwhelmed when they visualized Choregraphe as the platform offers numerous possibilities, however, they realized it was not as hard-to-use as expected. These findings concord with Bravo et al. (2017), who explains the challenges of text-based programming and how visual-based programming languages are beneficial for novice programmer users.

Concerning **RQ3:** *What are the university language instructors' experiences of the programming workshops?*, the answer to this question could be divided into instructors' experiences during the implementation sessions and experiences during the testing sessions. During the implementation, language instructors had positive experiences with the programming workshops. They considered they were well organized with clear objectives, and additionally, mentioned that the software was easy-to-use especially Elias Robot app. They found it was important that they were able to use their own ideas to decide which activities to implement with NAO for the students of Finnish Courses. This was a significant difference compared to previous studies (Chambers & Carbonaro, 2003; Kucuk & Sisman, 2018) which had pre-defined tasks designed by researches/specialists that educators had to complete in order to learn to program. In these studies, only the final project could be somehow related to educators' teaching activities but not the whole programming experience process. Finally, language instructors said that they had positive experiences regarding NAO's performance and progress. Even though participants were not expecting NAO to function perfectly, as one of them had previous experience with robots, they were happy about all the activities they were able to program and how consistently NAO worked.

Respecting the testing session, language instructors had both positive and obstructive experiences. The positive experiences were related to observing that many students wanted to interact with NAO, showing motivation and curiosity about the robot, as seen in previous studies reviewed by van den Berghe et al. (2019). In addition, P1 considered that it was beneficial that students had a long time to interact with NAO in some opportunities. Concerning the not-so-positive experiences, P1 mentioned that during the first testing session they heard that NAO had challenges understanding French accent. It is important to mention that NAO had difficulties with many accents and not only with French, it was visible during testing sessions that the robot struggled to understand people with different accents, and not only accents, but its speech recognition was also affected by stress of the words, intonation, volume, and speed. This aspect can also be related to the previous studies of Ahtinen & Kaipainen (2020) who encountered situations where children did not want to interact with the robot anymore as it could not understand them. In this master's thesis research, there were not situations where students did not want to interact with the robot due to its speech recognition, maybe because students in this research were older compared to the primary schoolers who participated in Ahtinen & Kaipainen (2020) research; however it was observed that some frustration was present when robot could not understand what they said after some trials.

Even though language instructors had positive experiences learning to program NAO over hands-on programming workshops, it is also possible to observe some ethical concerns. To begin, they said that they feel it is somehow odd to offer students a robot to practice their Finnish speaking skills while being in Finland when it would be easier to just invite to the classroom some native speaker who is behind the door. They also mentioned being concerned about how the robot can affect students speaking skills as currently, it can not recognize complex sentences and most of the time students needed to restrain their answers to one-word answers in order to be comprehended by NAO. This finding differs with Iio et al. (2019) who found that the use of the robot for 30 minutes per day for seven days, improve the speaking accuracy, fluency, and pronunciation of Japanese adults practicing their English skills. However, it is important to highlight that language instructors were only concern about this aspect, and they did not observe negative effects in students' speaking skills after they have used the robot. Additionally, it was also discussed that it is interesting to think about when a social robot is useful to learn languages and when it stops being useful. Language instructors said that they would use the robot in the future, with beginner students, as far as the activities presented by the robot and the interaction itself, could benefit the students somehow. However, they also mentioned that they can not find a valuable way to use NAO with more advanced students, as the possibilities that they have to interact are really diverse; and the objective of them as language instructors are to stimulate and facilitate this development, instead of restricting it, as it could happen with the use of the robot.

The overall research process and all the findings discovered throughout the master's thesis research, resulted in 12 implications for designing and implementing encouraging programming robotic learning application workshops for educators. Some of these guidelines have been defined by Schina et al. (2020) as best practices and confirmed by the master's thesis research. Additionally, they have been extended with the learnings of the research and are a valuable scientific contribution for future researchers who aim to design and implement encouraging workshop for educators. Even though these implications have been designed considering the subject of robots, they could also be extended to other domains.

8.3 Limitations and Future Work

As in every research, there were some limitations during this thesis. The first technical limitation was that the NAO object recognition function did not work as expected. NAO's cameras did work, and it was possible to observe in Choregraphe what NAO was seeing, however, after learning the objects shown to NAO, it could not store them in its memory and, hence, could not recognize them. Even though there are three samples of NAO6 in Robostudio, one is broken and the other one was being utilized in another research and at that time not available. In the future, it would be good to try this functionality with other NAOs to see if it works correctly and to be able to implement activities with this function.

Also regarding NAO's functionalities, another limitation was NAO speech recognition. During the research, it was truly visible that the robot has limitations in understanding people with diverse accents, stress, intonations, speech speed, and complex sentences. In addition, it also affects NAO's recognition, the placement of the robot in relationship with the user and how close/far the user speaks to NAO's microphones. An interesting fact is that most users immediately thought that its microphones were placed in its ears, instead of NAO's head, a fact that needed to be explained to each group interacting with NAO.

During the series of programming workshops, there were limitations related to the software Choregraphe. Language instructors were not able to install the software by themselves on their work computers, as they needed special authorization from the Information Technology department to install it or request them to do it. The problem was solved using our computer to program, however, in the future, it would be good if language instructors could have the software on their own devices in order to be able to access the activities and modify them accordingly to their own needs.

Furthermore, language instructors were not able to observe the interaction between NAO-students during the testing sessions. NAO needs a quiet environment in order to understand the speech better. Additionally, students who are not interacting with NAO at the moment would be distracted observing the interaction if it is happening in the main classroom. Considering those facts, it was decided to book an extra room where the interaction could take place, however, this setup disabled language instructors from observing the interaction. This aspect was discussed during the final focus group interview with them, and they proposed some solutions to solve this problem in the future including a) they could observe each other's classes, b) they would propose a separate practice session (however they are not sure if a lot of students would participate of it), and c) they could video record the session and watch the recording afterwards.

In this research, there were also some limitations regarding the number of participants who were involved in the research process. Even though the two language instructors who participated in this research were highly enthusiastic about learning to program the robot and participated in every single part of the research; in the future, it would be beneficial to conduct similar research with a larger number of participants. While conducting similar research, it would be useful to observe how a larger number of educators can work together to program robotic activities and how this factor could influence their learning experiences. Additionally, during this research, there were present some time constraints. As the robotic applications were aimed to be used with students to practice for their speaking test, there were only two weeks after the co-design session to design and implement the programming workshops, before starting evaluating them. Furthermore, after the implementation sessions ended, the testing sessions started immediately two days after that. This time constraint also allowed us to only have three implementation sessions, however, in the future, it would be also interesting to explore the positive and challenging experiences of a long-term robotic programming workshops intended for educators.

9 Conclusion

During this thesis research, it has been visible that conducting collaborative hands-on robotic programming workshops is a fast and easy way for educators to learn to program a social robot. In addition, making educators co-participants of the design of the workshop is a valuable and effective form to meet their needs and requirements, and to design programming workshops that covers the theoretical knowledge that they need for their teaching purposes. Some aspects that can be incorporated into programming workshops in order to help to maintain motivation during programming sessions are creating hands-on opportunities where educators can apply their programming knowledge from early on, as well as encouraging them to use their own ideas to design the robotic applications. It is also important to establish clear and concrete objectives for the participants, so they can visualize how and when the robotic applications would be used during their teaching activities. In addition, educators should use the workshop time to create their teaching materials, i.e., their robotic applications, and facilitators should provide them with theoretical material that could be used in the future.

This research also shows the importance of incorporating and making educators the designers and programmers of their own robotic applications, allowing them to produce them smoothly, and make instant modifications and improvements that will be beneficial for their students. Even though educators feel intrigued and eager to learn to program social robots by themselves, there are also concerns regarding how the robot could influence students' speaking skills and when the use of a robot stops being beneficial. Moreover, the importance of creating meaningful activities, where students can practice their own conversation skills as they would do with a native person, within a valuable and appropriate context, are some important considerations to keep in mind when designing robotic applications for language learning.

Additionally, despite the language students enjoy interacting with social robots to practice their speaking skills, considering social robots as "friendly", "interesting", and "simple", there are also some concerns regarding speech recognition, visualizing that the social robot NAO can not recognize different accents, word stress, intonation, complex sentences, or speech speed making the interaction somehow challenging. In the future it would be beneficial if the robot's speech recognition abilities are improved, allowing students to have a back-and-forth complex conversation, where students could learn thoroughly from and with the robot.

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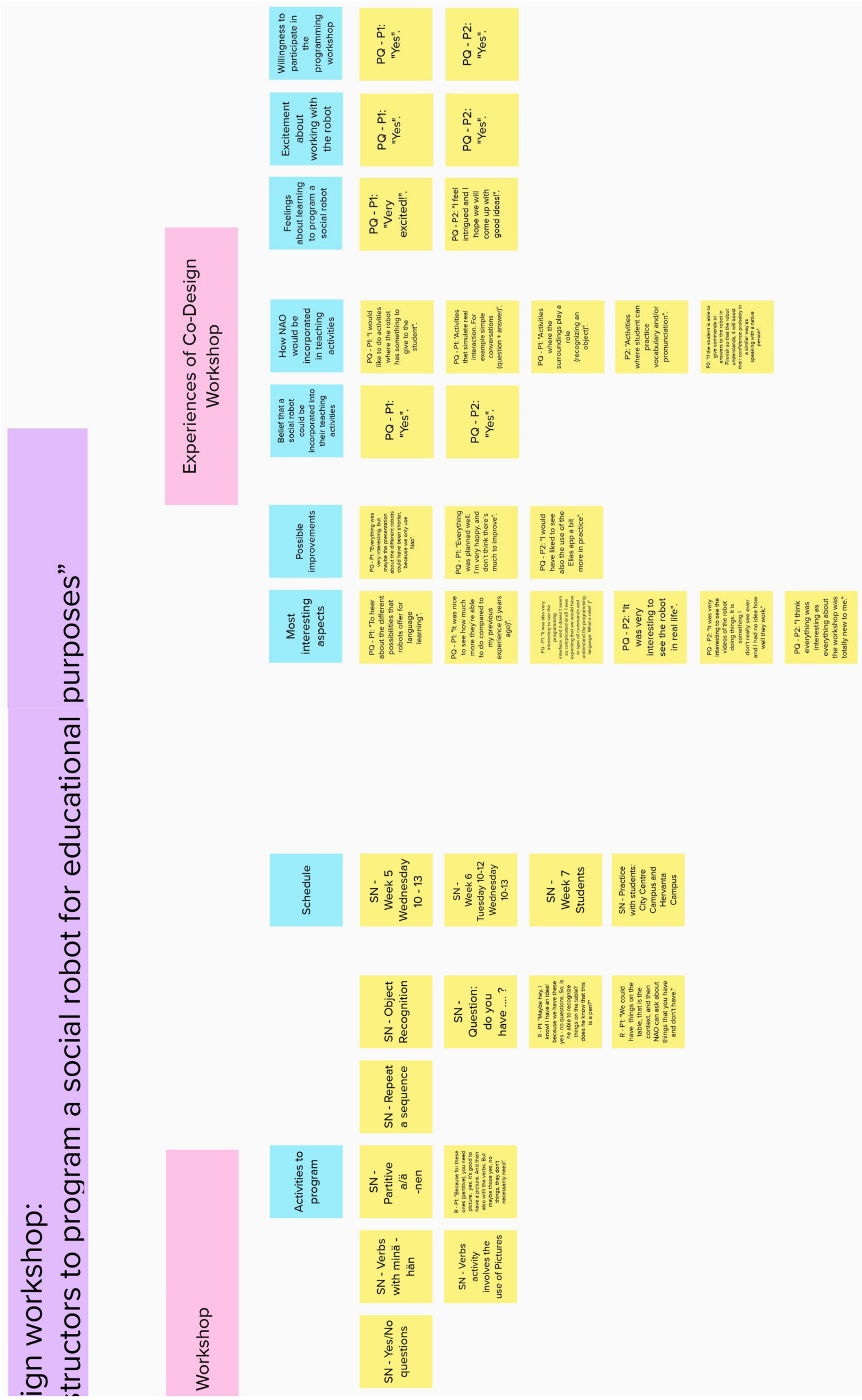
Appendices

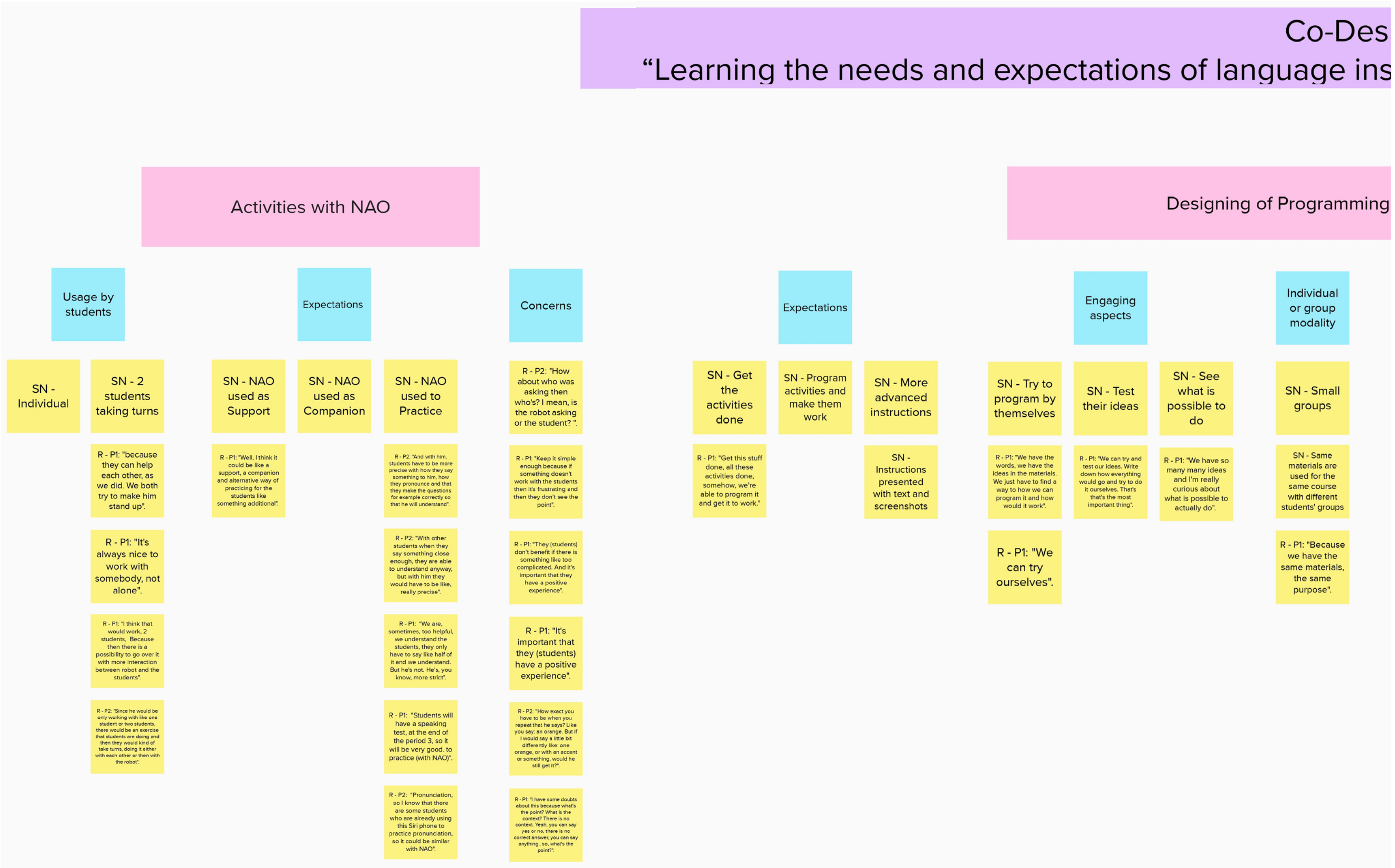
Appendix 1

Important links

- *Informed consent form for co-design workshop*
- *Background questionnaire for co-design workshop*
- *Post-workshop questionnaire for co-design workshop*
- *Affinity diagram of user study: co-design workshop*
- *Informed consent form for programming workshops*
- *Content analysis of design evaluation: programming workshops*

Appendix 2
Affinity diagram of user study




Co-Des
“Learning the needs and expectations of language ins
Activities with NAO
Usage by students
SN - Individual
SN - 2 students taking turns
R - P1: "because they can help each other, as we did. We both try to make him stand up".
R - P1: "It's always nice to work with somebody, not alone".
R - P1: "I think that would work, 2 students, Because then there is a possibility to go over it with more interaction between robot and the students".
R - P2: "Since he would be only working with like one student or two students, there would be an exercise that students are doing and then they would kind of take turns, doing it either with each other or then with the robot".
Expectations
SN - NAO used as Support
R - P1: "Well, I think it could be like a support, a companion and alternative way of practicing for the students like something additional".
SN - NAO used as Companion
SN - NAO used to Practice
R - P2: "And with him, students have to be more precise with how they say something to him, how they pronounce and that they make the questions for example correctly so that he will understand".
R - P2: "With other students when they say something close enough, they are able to understand anyway, but with him they would have to be like, really precise".
R - P1: "We are, sometimes, too helpful, we understand the students, they only have to say like half of it and we understand. But he's not. He's, you know, more strict".
R - P1: "Students will have a speaking test, at the end of the period 3, so it will be very good. to practice (with NAO)".
R - P2: "Pronunciation, so I know that there are some students who are already using this Siri phone to practice pronunciation, so it could be similar with NAO".
Concerns
R - P2: "How about who was asking then who's? I mean, is the robot asking or the student? ".
R - P1: "Keep it simple enough because if something doesn't work with the students then it's frustrating and then they don't see the point".
R - P1: "They (students) don't benefit if there is something like too complicated. And it's important that they have a positive experience".
R - P1: "It's important that they (students) have a positive experience".
R - P2: "How exact you have to be when you repeat that he says? Like you say: an orange. But if I would say a little bit differently like: one orange, or with an accent or something, would he still get it?".
R - P1: "I have some doubts about this because what's the point? What is the context? There is no context. Yeah, you can say yes or no, there is no correct answer, you can say anything.. so, what's the point?".
Designing of Programming
Expectations
SN - Get the activities done
R - P1: "Get this stuff done, all these activities done, somehow, we're able to program it and get it to work."
SN - Program activities and make them work
SN - More advanced instructions
SN - Instructions presented with text and screenshots
Engaging aspects
SN - Try to program by themselves
R - P1: "We have the words, we have the ideas in the materials. We just have to find a way to how we can program it and how would it work".
R - P1: "We can try ourselves".
SN - Test their ideas
R - P1: "We can try and test our ideas. Write down how everything would go and try to do it ourselves. That's that's the most important thing".
SN - See what is possible to do
R - P1: "We have so many many ideas and I'm really curious about what is possible to actually do".
Individual or group modality
SN - Small groups
SN - Same materials are used for the same course with different students' groups
R - P1: "Because we have the same materials, the same purpose".

Appendix 3
Learning journal template

THANK YOU FOR YOUR PARTICIPATION!

LEARNING JOURNAL

PROGRAMMING WORKSHOP: "LEARNING TO USE ELIAS APP AND CHOREGRAPHE FOR EDUCATIONAL PURPOSES"

SESSION N°1

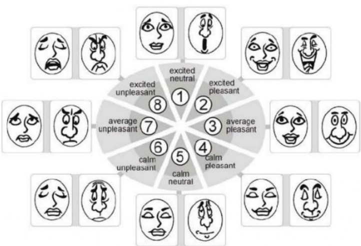
WHAT DID I LEARN TODAY?

WHAT WAS GOOD?

WHAT WAS CHALLENGING?

IS THERE SOMETHING YOU WOULD LIKE TO CHANGE FROM THIS SESSION?

HOW DID I FEEL TODAY?
Mark the correct (s) options.



SESSION N°6

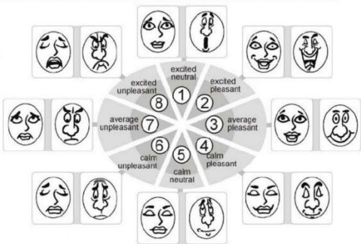
WHAT DID I LEARN TODAY?

WHAT WAS GOOD?

WHAT WAS CHALLENGING?

IS THERE SOMETHING YOU WOULD LIKE TO CHANGE FROM THIS SESSION?

HOW DID I FEEL TODAY?
Mark the correct (s) options.



Appendix 4
Focus group interview questions

Programming workshops:

- How was your overall experience of the programming workshops?
- What were the benefits of the programming workshops?
- What were the challenges of the programming workshops?
- What were the aspects that helped you, if any, to stay motivated during the sessions? How they helped you?
- What do you think about the duration of the programming workshops?
- Did you find Mural useful? Why do you think this way?

Co-Design workshop: (1st session where we talked about the activities that you would like to learn to program and how they would be presented to the students)

- Could you see the aspects discussed during the co-design workshop reflected in the programming workshops?
- Was it helpful to be able to influence the content and design of the programming workshops? Why?

Learning journal:

- How was the experience of writing in the learning journal?
- Did it help you to reflect on your own learning? How did it help?
- Do you think it was useful? Why do you think that?
- Do you think it was time-consuming? Why do you think that?

NAO in the classroom:

- How was the overall experience of using NAO in the classroom?
- What were the benefits of using NAO in the classroom?
- What were the challenges of using NAO in the classroom?
- How easy or hard was to think and design the activities to do with NAO?
- How easy or hard was to implement (program) the activities in NAO?
- Is NAO a suitable robot for your teaching purposes or would you need something else? Why do you think that?
- Would you recommend NAO to other language instructors?

Closing:

- Do you think you will use NAO in your classes in the future? How would you use it?
- Do you think you will implement more activities in NAO in the future?
- Do you have any extra comment?

Gratitude to participants, Robostudio team and Utelias.

Appendix 5
Observation table

Observation table Day:

First reaction when seeing NAO	
How do students interact with NAO?	
What expressions do students use while interacting with NAO?	
How do students seem to feel when interacting with NAO?	
Does NAO understand what students say?	
What do students seem to think about the activities?	
Unexpected happenings	
Extra info	

Appendix 6
Students questionnaire

Questionnaire: Using NAO Robot for learning purposes

I accept to be observed while interacting with NAO. My participation in this questionnaire is voluntary and anonymous. I accept that the findings of this study can be reported in the master's thesis of the Human-Technology Interaction student, Natalia Quintero. If you have any questions, please contact natalia.quintero@tuni.fi .

1. Please mark with a "O" your level of agreement with the following statements:

State-ment/Level of agreement	Strongly Disagree							Strongly Agree
Practicing my speaking skills with NAO was fun.	1	2	3	4	5	6	7	8
Practicing my speaking skills with NAO was smooth.	1	2	3	4	5	6	7	8
NAO could un-derstand what I said most of the time.	1	2	3	4	5	6	7	8
Checking my knowledge of the vocabulary with NAO was interesting.	1	2	3	4	5	6	7	8
The activities presented by NAO were suita-ble for my level of Finnish.	1	2	3	4	5	6	7	8
In the future, I would like to continue using NAO to learn languages.	1	2	3	4	5	6	7	8

2. Please mark your answer with a “O”:

I think the language learning 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
Fragile	1	2	3	4	5	6	7	8	Strong
Boring	1	2	3	4	5	6	7	8	Interesting
Basic	1	2	3	4	5	6	7	8	Advance
Hard to use	1	2	3	4	5	6	7	8	Easy to use
Unreliable	1	2	3	4	5	6	7	8	Reliable
Dangerous	1	2	3	4	5	6	7	8	Safe
Complicated	1	2	3	4	5	6	7	8	Simple
Unhelpful	1	2	3	4	5	6	7	8	Helpful
Uncontrollable	1	2	3	4	5	6	7	8	Controllable

3. Free comments about your experience using NAO

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