Second Language Tutoring using Social Robots

Project No. 688014

L2TOR

Second Language Tutoring using Social Robots

Grant Agreement Type: Collaborative Project
Grant Agreement Number: 688014

D1.1 Lesson Series for Three Domains

Due Date: **31/12/2016**
Submission Date: **23/01/2017**

Start date of project: **01/01/2016** Duration: **36 months**

Organisation name of lead contractor for this deliverable: **UU**

Responsible Person: **Ora Oudgenoeg-Paz, Josje Verhagen, Rianne Vlaar**
Revision: **1.0**

Project co-funded by the European Commission within the H2020 Framework Programme		
Dissemination Level		
PU	Public	**PU**
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	

Contents

Executive Summary

Development of a lesson series is one of the main aims of the L2TOR Project. We conducted an extensive literature review and pilot testing to determine the optimal way to use the L2TOR robot to facilitate second language learning in young children. This document discusses the detail of the lesson series we have developed so far as well as how specific decisions about the lessons have been made.

Principal Contributors

Plymouth	Tony Belpaeme, James Kennedy, Fotios Papadopoulos, Chris Montassier
Tilburg	Paul Vogt, Emiel Krahmer, Mirjam de Haas, Bram Willemsen en Jan de Wit
Bielefeld	Stefan Kopp, Thorsten Schodde, Kirsten Bergmann
Utrecht	Paul Leseman, Rianne Vlaar, Ora Oudgenoeg-Paz, Josje Verhagen, Sanne van der Ven
Koç	Aylin Küntay, Tilbe Göksun, Junko Kanero, Vasfiye Geckin, Cansu Oranç, Ezgi Mamus
Softbank	Jean-Marc Montanier, Amit Kumar Pandey

Revision History

Version 1.0 (Initials DD-MM-YYYY)
First and final version.

1 Introduction

Second language (L2) education is becoming increasingly important in many countries around the world, due to globalization and immigration. Preschool years are crucial for developing knowledge of school-relevant language, or academic language, which in turn influences later academic success (Hoff, 2013; Leseman & van der Boom, 1999). For children who speak another language at home than the language of schooling, developing proficiency in the academic language used at school can be a major challenge. To prevent language delays and lags in academic achievement, we must provide these children high-quality L2 input, when they enter preschool settings. The major aim of the L2TOR project is to develop a social robot that can support L2 learning, in particular young children's knowledge of L2 academic language.

In 2002, the EU formulated the long-term goal for every European citizen to develop functional language proficiency in at least two languages other than their mother tongue. These foreign languages should be taught from a young age (BEC, 2002). Most countries have opted for English as an L2 in preschool and primary education (Eurostat, 2016). However, implementing L2 classes into the existing curricula and classrooms is often not an easy task (i) only one teacher is typically available for teaching a large number of students, (ii) teachers often have limited proficiency in the L2 (or in the case of minority children, also in the L1), and (iii) there is enormous variation in children's L1 and L2 proficiency levels (Brühwiler & Blatchford, 2011; De Feyter & Winsler, 2009; Kim et al., 2014).

One-to-one tutoring has been shown to yield higher learning gains than group education (Bloom, 1984; VanLehn, 2011), but is often not feasible for financial reasons. One promising way to enable one-to-one tutoring while keeping the costs low involves the use of social robots for teaching. Social robots can convey verbal messages, use their bodies for visual cues such as gestures, and could thus be used to achieve a variety of educational goals. In fact, a number of studies have indicated that social robots yield higher learning gains than digital one-to-one screen-based techniques (Han et al., 2005; Hyun et al., 2008; Kennedy et al., 2015; Kose-Bagci et al., 2009; Leyzberg et al., 2012). There is no clear explanation for this effect, but it may be due to either the social and physical presence of the robot having a positive impact on the learner's engagement or the robot's multimodal features providing a richer and embodied pedagogical experience, or both factors. A general advantage of new technologies such as robots is that they allow for fast-paced and adaptive interaction, which is tailored to match the level and interests of the learner (Johnson, 2010).

In the case of L2 learning, an additional benefit would be that a robot can offer high-quality L2 input that human non-native speakers often are not be able to provide. Furthermore, robots could be programmed to make use of children's native language through using L1 words to support children's L2 learning. Providing support in L1 has been shown to be an effective strategy, enabling children to use their L1 knowledge to advance L2 learning (Schweers, 1999; Scot & de la Fuente, 2008). Finally, as the robot is situated in the physical world, interactions with a social robot can be multimodal (verbal,

visual, and tactile) and be focused on concrete objects and events in the world around the learner. As such, these interactions resemble the learning contexts in which children typically - and most often effortlessly - learn their native language.

2 Development of the lesson series

2.1 Objectives and procedure

A key objective in the L2TOR project is to develop three lesson series that are relevant, applicable, and feasible for L2 tutoring in a preschool setting. Each lesson series is to be implemented and evaluated for kindergartners (4- and 5-year-olds) representing five different L1-L2 language pairs: L1 German/L2 English, L1 Turkish/L2 German, L1 Dutch/L2 English, L1 Turkish/L2 Dutch, and L1 Turkish/L2 English. Our original plan was to design lesson series in the domains of number, space, and storytelling. In the course of the project, however, we decided to replace the storytelling domain with the domain of "mental state language", as will be explained further below. Thus, three lessons will be developed across the following three domains:

(1) Number domain - learning language about basic number and pre-mathematical concepts
(2) Space domain - learning language about basic spatial relations and movement
(3) Mental state domain - learning to express emotion and thought in language

In each lesson, the L2TOR robot, a NAO [1]robot tailored to the needs of the project, interacts with the child. The child and the robot play games together on a tablet, following a scenario that has been structured around a number of carefully selected L2 target words. These scenarios are written out dialogues between the robot and the child, containing opportunities for both the child and the robot to produce L2 words, make gestures, and perform actions on a tablet (see section 4 for more detailed descriptions of these lessons). Games are used in each lesson, next to short robot-child dialogues, to engage children in the lessons and elicit responses from them in a playful manner.

In the process of designing the general format of the lesson series, a number of decisions had to be made regarding, amongst others, type of instruction (implicit/explicit), the specific target words provided in each lesson, and the number of presentations of each target word. Decisions were based on the extant literature and data collected in two experiments (see section 2.2). Specifically, the design process involved four steps:

(1) Description of the three domains and identification of target words and expressions
(2) Design of overall theme and play scenes/actions/games in each lesson
(3) Pilot research
(4) Adjustment of the three lesson series on the basis of the pilots

The following sections provide a description for each of the four steps.

[1] Nao humanoid robot offered by SoftBank robotics, a partner in this project.

2.1.1 Description of the three domains and identification of target words and expressions

The choice of the three domains as indicated in the proposal was re-evaluated in a general meeting of the entire consortium at the start of the project, during which we decided to replace the storytelling domain with the domain of "mental states". Mental state words describe mental representations such as 'being happy' or 'being tired', and propositional attitudes such as 'think', 'love', and 'need'. Knowledge of mental states is closely related to Theory of Mind, which predicts later academic performance (Blair & Razza, 2007; de Villiers, 2007). The reason for replacing the storytelling domain with mental states was twofold. First, in all lessons, storytelling is sometimes used as a context for presenting the L2 words. Second, each lesson is embedded in an ongoing narrative (see section 4) and thus already includes some elements of storytelling. Second, mental state vocabulary is particularly important for young children because of its relation with academic performance as well as the fact that mental state words typically describe another person's states and attitudes, which make them an interesting case to be studied with an embodied robot tutor (rather than screen-based technologies).

Apart from the (re-)evaluation of the specific domains, Step 1 involved the identification of a set of L2 words and expressions to be taught to the children. To arrive at a sensible set of target words and expressions for each lesson, frequently used curricula, standard tests, and language corpora were used both for identifying potential targets and for checking these against age norms (see section 2.2 for a description of the target word selection process).

2.1.2 Design of the overall theme and play scenes/actions/games in each lesson

The overall theme and a global outline of the scenarios for the lesson series were designed in close collaboration between Utrecht University and Koç University. The main goal was to create an overall theme that would be familiar and appealing to most children, and as such, optimize children's engagement in the sessions. As the overall theme for the lesson series, it was decided to have a town that the robot and the child explore together. This town contains various shops, buildings, and other places that will be discovered one by one as the lesson proceeds. These are all locations familiar to young children, such as school and bakery. The robot and the child explore one location per session, by talking about it and performing games and exercises together. Stars are awarded after each completed session.

2.1.3 Pilot research

Three pilot experiments were carried out. The first experiment aimed to test whether children would learn a set of L2 words better with physical objects (i.e., toys) than with 3D virtual representations of these same objects on a tablet screen. This question was important to investigate in order to decide whether the NAO robot should be programmed to be able to recognize physical objects or whether 3D virtual representations of these objects would be sufficient for achieving the same learning gains. Two additional and interrelated questions were also investigated in this experiment: (1) How many L2 words can be presented in one session to kindergartners who do not have any L2 knowledge for

them to learn at least some of the words? and (2) How many occurrences of each target word are needed in order for children to learn the words?

The second experiment involved observations of human tutoring during adult-preschooler interactions about spatial relations. In this experiment, an adult tutor asked the child to place objects at various locations, and all instructions were given in L2. We examined how human adults naturally interact with young children and how children behave in an L2 learning environment. This experiment was carried out to determine the general structure of lessons as well as the target vocabulary for the spatial language lessons. We also analysed types of feedback adults used in teaching language to children.

The third pilot involved the testing of the experimental setup in the context of teaching German counting nouns to 4-5 years old English children. The setup consisted of a NAO robot, a touch screen and sensory hardware for data logging. The pilot served to assess the robustness of the hardware and software setup, and to observe the dynamics between the child and the robot. It also offered an opportunity to test our procedures and protocols related to deploying and running studies in a school environment.

2.1.4 Adjustment of the lesson series on the basis of the pilot experiments

The drafts of the lessons were adapted based on the pilot experiments, as well on the basis of input from the other consortium members. Input from the other consortium members included technical challenges regarding the programming of the robot, the main limitation being that the default speech recognition system that the NAO robots are equipped with is not capable of recognizing child speech (see: Kennedy et al., in press). This has major consequences for lesson development, as the interaction cannot build upon the robot understanding children's speech, responding to it, and online monitoring linguistic errors. To deal with this limitation, it was decided to use a tablet computer as an intermediate device through which the child and the robot can communicate. We will come back to this issue in the discussion where we will outline in more detail the implications of not being able to use automatic speech recognition in the L2TOR project (see section 5.2.2)

In the following sections, steps 1 to 4 in our procedure of developing the lesson series will be described in further detail. We will finish this report with a summary of the objectives obtained up to now, the challenges we are facing in developing the lesson series, and a work plan for further development of the lessons in collaboration with all partners.

2.2 Choice of target words

Choice of L2 target words involved three steps. First, an extensive study of educational curricula and standard tests was conducted for all three domains in order to make a first selection of words that are appropriate for 4-5 years-old children. Appropriate words are words that children should be familiar with in their L1, as the goal of the intervention is not to teach children new mathematical, spatial, and mental state concepts, but L2 labels for familiar concepts in the three domains. Math curricula were used to identify target words for the math domain. The standard language tests were used to identify words for the space domain. Literacy curricula were used to identify words for the mental states domain.

The curricula used were for selecting target words are:

- The British National curriculum for early years and Key-Stage 1 (children aged 3 to 7 years) (see: https://www.gov.uk/government/collections/national-curriculum)
- The SLO curriculum, which is one of the most frequently used curricula in Dutch schools (Buijs, Klep, & Noteboom, 2008)
- The road to mathematics – remedial programme for early mathematics in the Netherlands (Van Luit & Toll, 2013)

The standard tests used for selecting target words are:

- The CITO tests for literacy, maths and the spatial domain (CITO refers to the national student monitoring system in the Netherlands; Van Kuyk, 1992; 1996a; 1996b)
- The Dutch version of the McArthur-Bates Communicative Developmental Inventory (N-CDI, Zink & Lejaegere, 2002)
- The Turkish version of McArthur-Bates Communicative Developmental Inventory (TİGE, Acarlar et al., 2009).
- The Peabody Picture Vocabulary Tests (Dunn & Dunn, 1997; 2005)
- The Dutch Lexilijst (Schlichting & Lutje Spelberg, 2002)
- The Early Numeracy Test (Van Luit & Van de Rijt, 2009)
- The iPIPS (Centre for Education and Monitoring, Durham University, see: http://www.ipips.org; Van der Hoeven-van Doornum, 2005).

In addition, a small literature study was done in order to identify target words in the mental states domain that are appropriate for this age group (De Mulder, 2011; De Villiers, 2007; Shatz, Weliman, & Silber, 1983). This additional step was necessary, as the selection of words from this domain found in standard curricula and tests was not exhaustive. In the process of target word selection, words that are not lexically distinguished in one or more of the languages involved (e.g., smile and laugh in Turkish) were excluded, ensuring that all the words included are lexically distinct. Finally, the words included in the spatial domain were tested in a pilot study (see section 2.3).

In a second step, the log frequency counts of part of the chosen words were checked in several corpora. A complete list of the corpora used is provided in Appendix 1. For the math domain, extensive information was already available from curricula and standard tests regarding suitable words. Therefore, these words were only checked against a corpus of written child language in Dutch. For the spatial domain, an existing analysis (cf. Oudgenoeg-Paz, Leseman, & Volman, 2015) including 19 of the 31 words used in the lessons (about 60%) checked against several corpora of written and spoken adult and child language (see Appendix 1) was used. For the mental states domain, the words were checked against a corpus of spoken adult language and a corpus of written child language. The analyses were used to confirm that the chosen words were relatively frequent and therefore, probably known to young children. Words that turned out to be less frequent were excluded from the lessons.

Finally, the age of acquisition lists (Birchenough, Davies, & Connelly, 2016; Brysbaert, Stevens, De Deyne, Voorspoels, & Storms, 2014; Kuperman, Stadthagen-Gonzalez, & Brysbaert, 2012) were consulted for the age at which the selected words are acquired in Dutch, English, and German. These lists contain estimations of the age at which adult native speakers indicate to have acquired specific words. The English and

Dutch lists are based on the ratings of over 850,000 participants and the German list is based on ratings of about 540 participants. This method has been shown to provide a useful estimate for the age at which children acquire a given word. This estimation, in combination with the log frequency counts, provides a reliable estimate that can be used to design age appropriate activities (Brysbaert & Ghyselinck, 2006).

In sum, target word selection was based on whether words were present in curricula and corpora as well as age of acquisition ratings. All selected words are relatively frequent words, and expected to be acquired before the age of five. Using a combination of methods to identify appropriate target words enabled us to assume with reasonable certainty that the children know the target words in their L1. Hence, in the lessons, the children can focus on learning the words in L2, thereby building on the word knowledge already available in their L1.

The words chosen for the study were checked mainly in Dutch, English, and Turkish and to a limited degree also in German. However, given the high linguistic similarity between German, Dutch and English, all being Germanic languages, the chosen words should also be suitable for German children. Nevertheless, in the coming months, the words will be checked with our German partners to ensure they are indeed suitable for German children. Moreover, based on further pilot experiments, which will be conducted in the coming months, the words may be adjusted, for example if words turn out to be too difficult.

2.3 Pilot experiments with human tutors

2.3.1 Pilot experiment on spatial concepts

Children's understanding and production of spatial concepts (e.g., in, on) is subject to cognitive maturity (Farran & Atkinson, 2016). For instance, the understanding of categories for containment (in) emerges at around 6 months of age, the spatial category for support (on) emerges at around 14 months of age, and the understanding of other categories such as between emerge at around 10 months of age (Clark, 2003). Once the conceptual apparatus is in place, spatial concepts get sharpened via linguistic interactions through the preschool years. To create an effective learning environment that involves social robots, we first need to understand how human L2 tutoring that involves spatial concepts and terms proceeds. Hence, we conducted a pilot experiment with human tutors. The aim of this human L2 tutoring pilot study was twofold: (1) examine children's comprehension of spatial relations in L2 in comparison to their comprehension of these spatial relations in L1 (2) identify the kind of interaction patterns (i.e., feedback mechanisms) that take place between the child and the human tutor in an L2 learning environment. The pilot study also enabled us to examine children's knowledge of spatial relations in both L1 and L2, and to track the difficulty levels of different spatial relations (e.g., in vs. behind).

To reach these goals, we designed a new and engaging game-like task based on the hide-and-seek game. We created real, authentic and tangible objects for children to explore the spatial relations in a fun and curiosity-invoking environment. The hide-and-seek game consisted of two training sessions and a total of 24 test items presented in four games. In each game, the child was instructed to locate six different animal figures in a garden hosting several background objects. Six different spatial relations were tested: *in*, *on*, *under*, *next to*, *behind*, and *between*. Figure 1 shows a sample scene from the study.

Figure 1. A sample scene from the second pilot study. The instruction given to the child was "put the giraffe in the lake."

A total of 20 children participated who attended a preschool in Istanbul at the time of testing (*M* = 68.9 months, age range = 51-77 months, *SD* = 8.3). These children had attended English classes twice a week at school, with each class lasting 30 minutes. Therefore, they already had some knowledge of English as L2. The parents reported that children's daily exposure to English at home ranged from 5% to 20%. Children were tested individually in a quiet room in their school. The children were first tested in English and then in Turkish (with slightly different versions of the game) in two sessions, conducted one week apart. Each session lasted 15-20 minutes.

We transcribed and coded the sessions conducted in L1 (Turkish) and L2 (English) from the videos. Two variables were coded: (a) accuracy in comprehending spatial relations was coded as correct without feedback, correct with feedback, and incorrect, and (b) feedback type was coded as encouragement, pointing, modelling, guiding questions, warning, elicitation, and repetition. We also examined how well children benefited from each feedback type.

Results showed that without any feedback children comprehended the spatial relations 'in', 'on', and 'under' more accurately than the relations 'behind', 'between', and 'next to', in both languages. Children performed most accurately on items with 'in' in Turkish (100%) and in English (30%) and the least accurately on items with 'next to' in Turkish (70%) and in English (5%). Feedback improved children's accuracy significantly with all spatial relations, except the items with 'behind.' In particular, children's correct responses increased as a result of pointing. With other types of feedback, only the items with 'next to' were comprehended better than without feedback. Further, more encouragement phrases (e.g., "Try again," "Do it," "Come on") were given when the child's performance was low. These findings suggest that (1) children have similar learning trajectories in both L1 and L2, (2) children's performance was not affected by the increasing number of feedback given, and (3) accuracy in comprehending spatial relations was related to the complexity of the spatial concepts suggested by previous literature (Johston & Slobin, 1979).

These results from the pilot study provided information for the lesson series in robot-child interactive contexts. In particular, the findings are helpful to determine the feedback strategies to be implemented in the lesson scripts. For instance, we avoided using encouragement phrases such as “try again” in the scripts, due to its negative effect on children’s performance. The study also revealed that children lost attention if a session lasted longer than 30 minutes. Thus, we shortened the duration of sessions and if necessary, decreased the number of target words. Furthermore, having observed the children’s hesitance in the game when they were tested only in L2, we decided to increase the use of L1 phrases and words in the tutoring part and to teach words in pairs to highlight the difference between the two spatial concepts (e.g., under/over and up/down).

2.3.2 Pilot experiment on the use of pictures on a tablet versus physical objects

The second pilot experiment was conducted to examine the use of objects and tablets in learning interactions. One major decision that needs to be made is whether children will manipulate physical objects during the lessons or only perform manipulations of object pictures on a tablet. In order to make an informed decision on this issue, we conducted a pilot experiment on L2 vocabulary learning with tablets versus objects. The main research question in this pilot study was whether there was a difference in L2 vocabulary learning gains between children who manipulated physical objects and children who manipulated pictures of these objects on a tablet screen. It is highly important to address this question as current technology does not yet enable the NAO robot to easily perceive and, especially, manipulate objects. Making this possible requires a significant amount of work from the technical partners. Therefore, it is important to first test whether children actually benefit from manipulating physical objects during L2 training more than from manipulating pictures on a tablet, before deciding about incorporating physical objects in the lessons.

According to the embodied cognition approach, language is grounded in real-life sensorimotor interactions. Therefore, it is expected that interaction with real-life objects will be favorable for children’s vocabulary learning (see for example: Glenberg, 2008; Hockema & Smith, 2009; Kersten & Smith, 2002). Some empirical evidence supports the idea that objects are important for learning nouns and verbs in young children (e.g., Kersten & Smith, 2002). It is, however, not yet clear whether manipulating virtual 3D objects on a tablet provides the same learning experiences/opportunities for young children as manipulating real-life, 3-dimensional objects when learning new words. The main objective of the pilot was to gain insight into this question to provide us with the necessary information for the L2TOR interaction design. However, the pilot also enabled us to test a lesson with 4- and 5-year-olds and see how many target words and how many occurrences of each target word could be included in one session to facilitate word learning.

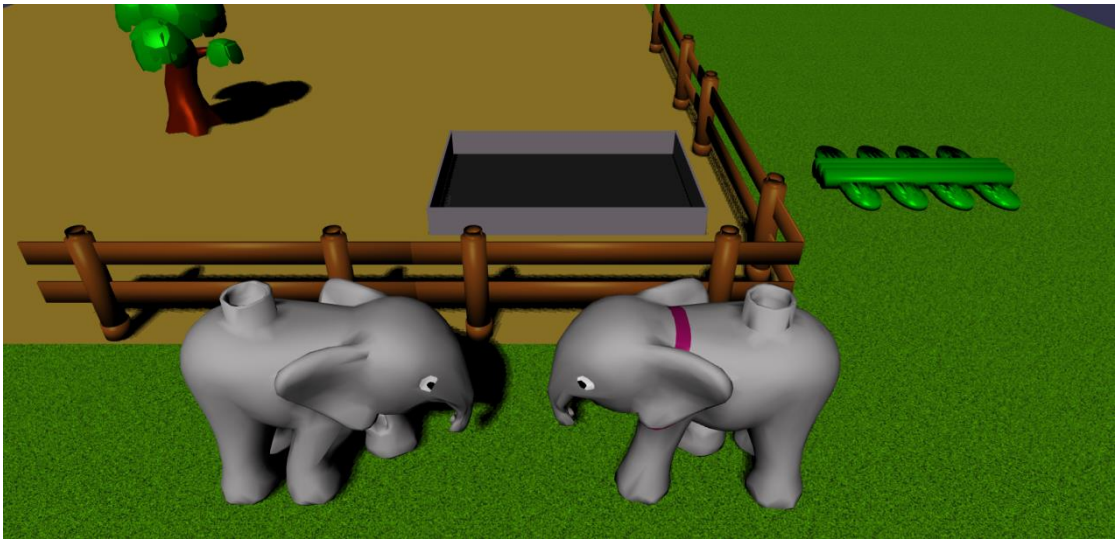

Figure 2. Scene from the tablet condition. In this scene the child is asked to place the elephants in their yard. They are told that the mother elephant (the one with a ribbon around the neck) is heavy because she has a baby in her tummy. The child is then taught that 'heavy' is the English word for heavy. In the real objects condition the child sees the same scenery on a paper and physically moves the elephants. In the object's condition the child can feel that the mother elephant is heavy (as the elephant representing the mother is filled with sand).

So far, 37 Dutch kindergarten children (*M* = 61.4 months, age range = 51-72 months, *SD* = 6.77) took part in this study. These children did not have any knowledge of the L2 (English). The experiment consisted of a pre-test, followed immediately by a training and a post-test. One week later, a second post-test was conducted. During the pre-test the children were tested to make sure they did not already know the target words included in the training. During the post-test following the training and the delayed post-test conducted one week later the children were tested on their knowledge of the target words.

The training included six English words: 'heavy', 'light', 'full', 'empty', 'in front of,' and 'behind'. The target words were embedded in a narrative, with set opportunities for the child to manipulate either objects on the tablet or physical objects. Figure 2 provides an example of a scene from the tablet condition.

The post-test included several tasks to measure the learning gains: two translation tasks (one from English to Dutch and the other from Dutch to English), a comprehension task in which the picture corresponding to the target word had to be picked out of four options, and a sorting task in which the child had to decide for ten pictures whether the target word was depicted or not.

Preliminary results indicate that there is no apparent disadvantage of using a tablet over physical objects, as indicated by comparisons of children's accuracy scores on the immediate and delayed post-tests. However, data collection is still ongoing, and more data need to be analysed before we can draw firm conclusions.

While designing the experiment, we based the number of target words offered in our vocabulary training on existent literature (e.g., Marulis & Neuman, 2010). Even though

there is quite some evidence regarding the number of words that should be offered during a (L1) vocabulary intervention with young children, there is virtually no literature on the number of times a word should be repeated for the child to learn the word. The first version of our vocabulary training, therefore, contained ten words that were each presented six times. We chose to present each word six times during the training, as this allowed us to create a meaningful context without making the training too long, and avoid fatigue.

After testing only five children, it already became clear that ten target words were too much and six occurrences were too few for children to learn any words. The children seemed overwhelmed with the task of learning words in a language they had no experience in. Therefore, the amount of target words was reduced to six and the amount of occurrences increased to ten times for every target word. So far, 32 children have been tested using the new vocabulary intervention. Even though learning gains are still small, children are now learning some target words. In the direct translation tasks (which are quite challenging for children of that age), the children generally provide the correct answer for one or two words. In the comprehension task and the sorting task, they score well above chance level.

Another element that is relevant for lesson development is the context in which the target words are embedded. In the training, the target words were embedded in a narrative. However, the children in the pilot experiment seemed to have trouble focusing on the target words because of the narrative. The narrative context may actually distract the children from the target word instead of helping them to learn it. This led to the decision to focus more on games as a way of teaching and practicing the L2 words in the lesson series instead of narratives. Game settings allow more easily for more target word occurrences and repetitive manipulations in comparison with narratives, as children mostly have to listen and cannot manipulate that much when a narrative is used, while, in a game, such manipulation and acting out can be part of the game. Summarizing, although we cannot yet draw strong conclusions regarding the question of whether physical objects yield higher vocabulary learning gains than a tablet in 4- and 5-year-olds without any prior knowledge of the L2, this experiment has already provided some valuable information regarding other aspects of the lesson development.

2.3.3 A Wizard of Oz pilot study on number domain

The third pilot study was conducted in a UK primary school to evaluate children's pronunciation while counting up to five in German. This task involved multiple steps to gradually teach children to count up to five by utilizing a colourful task with animals (Figure 4). The first step of the task introduced the robot-tablet concept and instructed the children on how and when to provide answers. Since this is an early stage of the project, we decided to follow a Wizard of Oz (WoZ) approach to control the interaction and the robot. This strategy provides better insights into how the robot should respond, enabling us to build an autonomous interaction manager based on sensory input later on in the project. The main task involved animal counting in English and then in German. The WoZ operator provided the appropriate help and feedback when it was required by using a control panel on another computer. At the end of the task the robot asked the children to count up to five again with the robot's help and then without any help at all. The purpose of this step was to

evaluate if the children could remember the pronunciation of the German numbers after some time and if they could repeat them without any help.

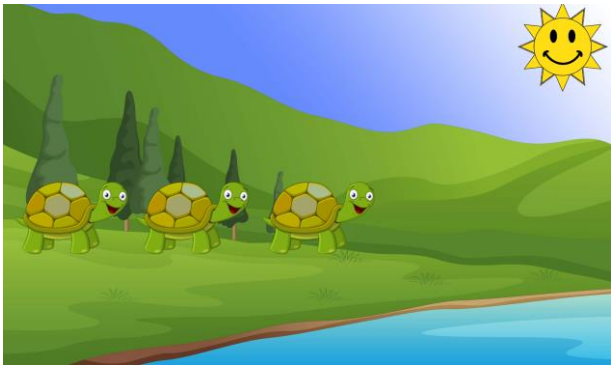

Figure 4. Counting study game interface on the tablet

During the study, we recorded audio data and a frontal HD video from a Kinect sensor along with skeleton and depth data. Additionally, we recorded a video with a camcorder positioned diagonally from the children.

We ran the study with 8 children, aged 5 years old. After the study we ran some analyses to explore the human-robot interaction and generally evaluate the technology in a real school environment. One observation was that repetitions can improve pronunciation as children initially find it hard to pronounce German, but perform better after multiple repetitions at the end of the session. Additionally, we found that children struggle to switch from English to German instantly as they sometimes count in German instead of using English. Using data from the depth sensor of the Kinect it became clear that children who sat away from the tablet/robot did not engage or perform as well as children sitting more closely to the tablet/robot. Finally, the data showed that children found it difficult to concentrate on both the tablet and the robot at the same time. This finding will be further investigated in future experiments, to get a better understanding of children's trouble with dealing with a tablet and a robot simultaneously.

3 Structure of lesson series

Three lesson series, one per domain, were designed to teach an L2 to 4- to 5-year-old children in Germany, the Netherlands, and Turkey. All lessons were first developed for English teaching. English was chosen as the first target because it is the most commonly taught L2 in Europe. English would provide the most generalizable example on how an L2 should be taught, and learning English should also be beneficial for children who participate in this project. These lessons, however, will also be adapted to the lessons for Turkish immigrant children who are learning German or Dutch. Testing Turkish immigrant children will allow us to evaluate the use of social robots in L2 teaching in a common situation ethnic minority children experience. In summary, lessons will be implemented for five L1-L2 pairs. Native speakers of German, Dutch, and Turkish (living in Germany, the Netherlands, and Turkey, respectively) will be taught English whereas Turkish (immigrant) children in Germany and the Netherlands will be taught Dutch or German.

For each lesson, the NAO robot will communicate with the child following a specified scenario. These scenarios describe the general sequence of targets that L2TOR

aims to achieve by interacting with the child. Each domain consists of three lessons, of which two are used to teach children new vocabulary and one is used to repeat all the target words of that domain. The two lessons with new vocabulary are divided over three sessions each, so the vocabulary of one domain is taught over a total of six sessions. The recap lesson consists of two sessions. This makes a total of eight sessions per domain and twenty-four sessions in total for the whole lesson series. See Figure 5 for a schematic presentation of the lesson plan per domain.

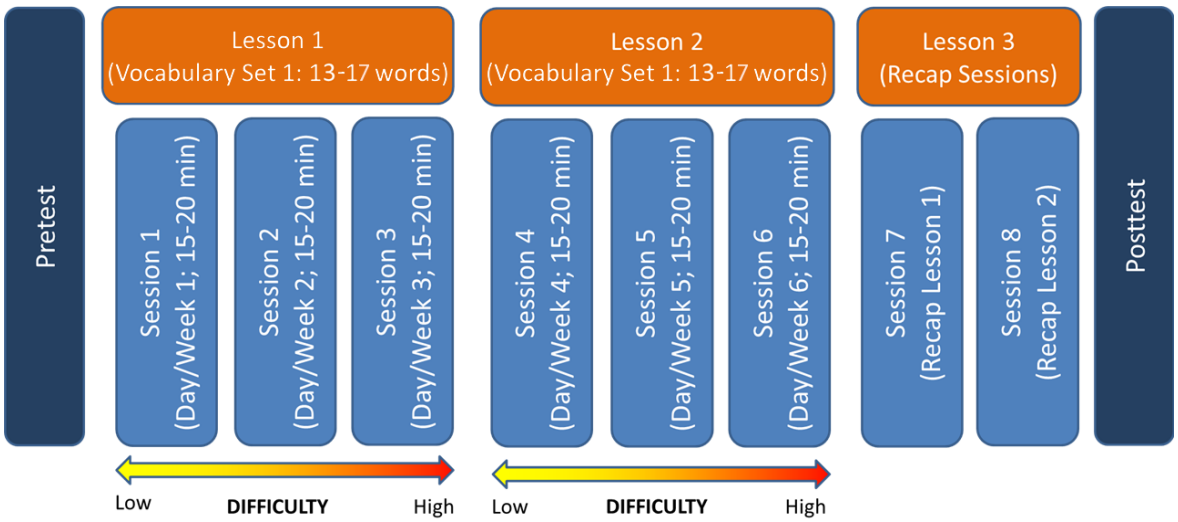

Figure 5. Structure of lesson plan for each target domain.

In addition, two sessions of introduction to the robot are included before the lesson series start. These sessions involve the whole class (first session) and small groups of children (second session). Our first experiences in introducing the robot to kindergarten children have shown that some children are a bit wary of the robot and most of them need time to get used to it. The introductory sessions allow the children to get used to the robot and learn how it can communicate with them. The design process of scenarios involved four stages: 1) description of the three content domains and identification of target words, target expressions and related support actions (e.g. pointing to, handling of, and grouping of objects) within each domain, 2) design of play scenes containing objects and spatial structures for child-robot interactions and interaction scenarios around the target words and related actions, 3) pilot research and formative evaluation in small samples in each language group, using observations and interviews with children, parents and teachers, and 4) adjustment of the three lesson series based on the results of the pilots. Below, we describe how we made decisions about the scenarios and provide examples of lesson scenarios. It must be noted, however, that these scenarios may need to be revised in future based on the results of pilot testing. We also plan to make the lessons more adaptive, i.e., the robot will adjust its speech and gestures based on the child's performance. The exact nature of the adaptive interaction will be determined after careful consideration of technical feasibility in Work Package 5.

3.1 Target Domains

Preschool years are important to develop adequate knowledge of the academic language as later educational success builds on it (Esser, 2006; Hoff, 2013; Leseman & van der Boom, 1999). For the L2TOR project, three domains were chosen to meet the educational needs of preschool children, and also for their relevance and applicability in second language tutoring. These were 1) numbers and pre-mathematical concepts, 2) spatial language, and 3) basic vocabulary learning to understand mental states. For each domain, three lesson series were defined, such as counting numbers or spatial prepositions (in, on, over, etc.). Each lesson contained three sessions that were designed as scripts of interactive games. Thus, for each target domain, children will receive 9 sessions. Throughout the tutoring lesson series, children will be provided with increasingly complex stimuli and utterances in the second language, as well as appropriate feedback from the robot that supports the child's language development.

To support children's knowledge of L2 academic language, math was chosen as the first domain. It aims to introduce mathematical concepts and terms in L2, which are already acquired in L1. In the math domain, lessons include counting objects, comparing numbers, and performing simple operations such as additions and subtractions. The "space" domain is related to learning of language about basic spatial relations. This was chosen as the second domain because not only spatial language is used frequently in everyday conversation but also lays the foundation for STEM learning and influences academic success (Hegarty, Keehner, Khooshabeh & Montello, 2009; Kozhevnikov, Motes & Hegarty, 2007; Wanzel et al., 2002). It has also been suggested that spatial conceptual development is reinforced by the acquisition of spatial language (Pruden, Levine, & Huttenlocher, 2012). Our previous research also found that the breadth and depth of exploration of spatial relations predict spatial cognition and spatial language development and to mediate between children's motor skills and language outcomes (Hellendoorn et al., 2015; Oudgenoeg-Paz et al., 2015). We chose "mental state language" as the third domain instead of the storytelling domain because of its relation to academic achievement and its feasibility of testing. As we stated earlier, knowledge of mental representations of others is linked to Theory of Mind, which predicts later academic performance (Blair & Razza, 2007; de Villiers, 2007). In the mental states domain, lessons include mental representations such as 'being happy' or 'being tired', and propositional attitudes such as 'know' and 'need.'

3.2 Target group

Our target audience is children between 48 and 72 months of age. This age range, however, may be revised based on the current and future pilot experiments. In the pilot experiment concerning tablets and objects (see section 2.3.2.), we already observed some of the younger children struggling to manipulate the tablet.

As briefly mentioned earlier, we will examine two different types of L2 learners, with a total of five different language combinations. One type of learners involves the children who have no experience in the L2. They are the Dutch-, German-, and Turkish-speaking children learning English as an L2. The other type of learners involves immigrant children that may have already acquired some L2 from their environment. For this category, we will test Turkish children in the Netherlands or Germany who are learning Dutch or German respectively. At this stage, we are primarily focusing on the first group -

Dutch, German, and Turkish children with no prior experience of learning English. We decided to focus on this population for two reasons. First, most young children in the Netherlands and Germany are not be exposed to English at age 4. Second, if we successfully develop lessons that work for children with minimal exposure to English, those lessons can also be used for children with some prior English knowledge whereas the other way around would be very difficult.

In the lessons we currently have, the interaction is almost solely in the L1 because the children we target have no previous L2 experience. After the lessons will have been validated, the lesson series will be further developed to also suit the other group: children with some L2 exposure. Children in the latter group may not need the whole interaction in their L1, but there would also be some individual differences. Thus, we have to make the lessons adaptive to make use of the children's L1, based on their L2 vocabulary levels. True adaptivity would depend on each child's vocabulary and is difficult to reach, but we will identify moments in the interaction which could be either in the L1 or in the L2, based on the L2 level of the child.

3.3 Role of robot and tablet

3.3.1 Role of robot

Our robot will be introduced as a peer, of the child and will participate in the lessons together with the child. There are several possible roles social robots can play in educational settings. For the L2TOR project, the two options are a robot as a teacher who teaches L2 to the child and a robot as a peer who learns L2 together with the child. Though both options have been explored in the literature, previous research with older children demonstrates that children are more engaged and learn better when a robot acts as a peer (Zaga, Lohse, Truong, & Evers, 2015). Although no study has compared the effectiveness of the teacher robot and the peer robot for 4- and 5-year-olds, children are known to learn from their peer even at a very young age not only in real but also in virtual worlds (Ryokai, Vaucelle, & Cassell, 2003). It has also been shown that many teachers have negative attitudes towards the use of robots in the classroom partially because they are afraid of the robot taking over their work (Reich-Stiebert & Eyssel, 2016). Introducing the robot as the child's peer is expected to reduce the negative attitude and create more positive learning environment for children. The robot will, however, be a peer who knows slightly more than the child and can therefore provide scaffolding. The robot can scaffold information in an adult-like manner, while still acting like a peer, thus ensuring that the child's learning is as effective as possible. Moreover, the peer robot could occasionally make errors, creating opportunities for the child to correct the robot.

3.3.2 Role of tablet

The tablet provides playful learning activities and introduces words and phrases in English. The visual stimuli would be kept as simple as possible to ensure that the child pays attention not only to the tablet, but also to the robot. Although very common in commercial educational apps, we chose not to depict an animated character on the tablet because a three-way interaction involving the robot and animation character can be difficult for young children. However, as we are still evaluating the possible use of tangible objects (see section 2.3.2), the exact role of the tablet will be determined later.

3.4 Number of target words within lessons

We first decided on the number of L2 target words for each lesson based on the literature (see section 3.1). According to a recent meta-analysis of effects of vocabulary interventions on young children's vocabulary learning, interventions should contain five to ten target words per session (Marulis & Neuman, 2010). We tested this recommendation in our pilot on vocabulary learning with a tablet versus physical objects (see section 2.3.2), and noticed that ten target words were too many for kindergarten children.

Therefore, we decided to decrease the amount of target words not only in the experiment, but also in the lesson series. A possible explanation for the lack of learning gains in our experiment is that the participating children in this experiment were Dutch kindergartners that did not have any prior knowledge of the L2 (English). This makes our study significantly different from most studies as reviewed by Marulis and Neuman (2010). Many interventions are aimed at further expanding children's vocabulary in their L1, instead of teaching first words in an L2. We hypothesize that children without any prior L2 knowledge could be overwhelmed more quickly as the task of learning L2 words could be more difficult than learning words in L1.

3.5 Frequency of target words within lessons

As noted in section 3.1, there is, to the best of our knowledge, no literature on the number of times a word should be repeated for the child to learn the word. In our pilot experiment, children started learning words once we lowered the number of target words and increased the frequency of repeating target words from six to ten in one session. However, children still do not learn all target words in one session. This indicates that children need repeated exposure to the target words, which helps them in processing and storing new words (Marulis & Neuman, 2010; National Reading Panel, 2000; Trovimovich & Gatbonton, 2006). For this reason, in the lesson series, the children will be exposed to the target words in later sessions as well, in addition to the recap lesson. Each target word will be repeated in regular sessions at two later moments: in either one of the two sessions directly after the target session, and in a session in a different domain. In addition, they are repeated in the recap sessions. Words in the mental states domain, the last domain of the lesson series, are repeated twice within their own domain as well as during the recap lesson.

3.6 Duration of the session

We originally planned the duration of one lesson session to be about 30 minutes. Our pilot studies, however, suggested that 30 minutes was too long for 4-year-olds, and they experienced fatigue and frustration. Therefore, we have decided to reduce the duration of one session to 20 minutes at maximum. We also aim to make each session as short as possible because preschoolers' attention span is quite limited (Mahone & Schneider, 2012).

3.7 Adaptivity

In the final version of the lessons the robot should be able to adaptively respond to children's actions in order to provide them with increasingly complex stimuli and utterances in the second language, as well as appropriate feedback that supports the child's language development. The system will keep track of the child's progress and tailor the

tutoring accordingly. At the moment, some adaptive elements were inserted in the lessons (see appendix 2). For example, if the child is does repeat a word when asked to do so, the robot encourages the child to do so, gradually providing more scaffolding. WP 5 is working on the interaction manager component of the architecture which is responsible for planning and choosing the system reactions. In collaboration with WP5 the lessons will be further developed and be made more adaptive. Possible aspects of the lessons that can used to make them adaptive include for example: increasing or decreasing the number of repetitions of target words, adjusting the level of scaffolding provided by the robot and recap of target words from previous lessons (i.e., words the child struggled with will be introduced more often in the following lessons).

4 Target Words and Activities per Domain

Below, we describe the content of the lessons in terms of the words and activities provided in each lesson and per domain. For examples of these lessons, see Appendix 2.

4.1 Math domain

Mathematical language does not only consist of number words, but also involves words describing mathematical concepts like operations, quantities, size, weight, and contents. As noted in section 2.2, target words for this domain were selected based on Dutch math curricula. Specifically, they were chosen in such a way that all children participating in the lessons are assumed to be familiar with the concepts in their L1 as these concepts being very frequent and early acquired notions. This is important, as the focus of the lessons is to teach the children L2 labels for familiar mathematical concepts rather than teaching new concepts. The next two sections will describe the target words used in each session and the activities used to teach children the target words.

Table 1.
List of target word per lesson in the math domain.

Lesson 1			**Lesson 2**		
Session 1	**Session 2**	**Session 3**	**Session 1**	**Session 2**	**Session 3**
One	four	eight	Big	bigger – biggest	Full
Two	five	nine	Small	smaller - smallest	empty
Three	six	ten	Light	lighter – lightest	Filling
More	seven	most	Heavy	heavier – heaviest	emptying
Add	fewer	least	high	higher – highest	too full/much
	take away	as many	Low	lower – lowest	

Table 2.
Setting and activities per lesson in the math domain.

Lesson	**Session**	**Setting**	**Activity**	**Task example**
Lesson 1	Session 1	Zoo	Putting animals into the cage	counting them while putting them in the cage, adding animals

Lesson 1	Session 2	Flower shop	Making a bouquet	practice of numbers 1 – 7), adding and taking away flowers, more and fewer flowers are needed
Lesson 1	Session 3	Aquarium	Putting fish in tanks	practice of numbers 1 – 10, multiple tanks have different number of fish, which has most, least, making sure all tanks have the same number of fish.
Lesson 2	Session 1	Bakery	Baking	comparing big and small cakes/bags of flour, big ones are heavy, small ones are light, light ones go on the high shelf, heavy ones go on the low shelf
Lesson 2	Session 2	Fire station	Extinguishing fire	fire grows bigger or smaller, water hose is heavy and gets lighter, water hose should be aimed higher or lower
Lesson 2	Session 3	Farm	Feeding animals	filling their drink/food trays with water/food

4.1.1 List of target words

The target words to be taught in the math lessons involve number words, quantity words, words expressing operations (e.g., subtract), adjectives, and comparative degree words. Table 1 lists the target words and shows in which lesson and session these are provided. The distribution of words over the sessions is such that words and concepts become more difficult as the child proceeds through the lesson series. The difficulty level of the words was determined according to the Dutch math curricula.

4.1.2 List of activities

We chose several locations and games for the children that provide a meaningful context to learn the target words. Table 2 shows an overview of the lessons and sessions and the activities that are presented in each session. The settings are all part of a town that the robot and the child are exploring together. The setting of the town is used across all three domains.

4.2. Space Domain

The space domain concerns learning of language about basic spatial relations. In the space domain, learning targets range from exploring spatial relations between objects from an egocentric perspective (preposition and movement verbs), to spatial relations from an allocentric perspective (navigation through space and perspective taking), and performing a construction task (building a model with blocks) following instructions involving spatial relations.

4.2.1. List of target words

In the space domain, we teach spatial prepositions (e.g., *in*), motion verbs (e.g., *run*), and adverbs (e.g., up). Table 3 provides a list of target words and indicates in which lesson and session these words are introduced. The words are distributed across sessions such that the difficulty level increase as the child proceeds through the lesson.

Table 3.
List of target word per lesson in the space domain.

Lesson 1			**Lesson 2**		
Session 1	**Session 2**	**Session 3**	**Session 1**	**Session 2**	**Session 3**
in	across	over	walk	fall	slide
on	left	under	run	skip	throw
between	right	up	swim	fly	catch
next to	front	down	jump	crawl	climb
above	behind	around	kick	hop	swing
below		through			

4.2.2 List of activities

Similar to the activities in the math domain, six locational settings and activities were chosen for the spatial language lesson (Table 4).

Table 4.
Setting and activities per lesson in the math domain.

Lesson	**Session**	**Setting**	**Activity**	**Task example**
Lesson 1	Session 1	Fruit shop	Organizing fruits	Putting fruits at various locations in the shop following instructions
Lesson 1	Session 2	Restaurant	Serving customers	Putting objects such as plates and glasses following instructions
Lesson 1	Session 3	Mountain	Climbing the mountain	Performing actions to avoid obstacles (e.g., jumping over a log) climbing up a mountain
Lesson 2	Session 1	Swimming pool	Charades	Guessing actions and gestures performed by the robot
Lesson 2	Session 2	Forest	Tracing animals	Exploring the forest and finding animals
Lesson 2	Session 3	Playground	Building a playground	Placing play equipment such as slide and swing in the playground

4.3 Mental states domain

Mental states language includes words that describe people's emotions, intentions, beliefs, thoughts and knowledge. This domain thus includes words describing emotions

and emotional verbs such as '*happy'* or *'cry'*, as well words referring to intention such as '*want'* and words referring to (the level of certainty) in what people know such as *'know'* or *´think'*. As described in section 2.2, target words for this domain were selected based on literacy curricula, standard vocabulary tests and a review of relevant literature. The chosen words are all highly frequent and relatively early acquired. Thus, these are words that 4- and 5-year-old children are likely to be familiar with in their L1. The next two sections will describe the target words used in each session and the activities used to teach children the target words.

Table 5.
List of target word per lesson in the Mental States domain.

Lesson 1			**Lesson 2**		
Session 1	**Session 2**	**Session 3**	**Session 1**	**Session 2**	**Session 3**
happy	laugh	hungry	scared	know	Want
sad	cry	tired/sleepy	surprised	think	Need
angry	you are	thirsty	he	we	Like
I am	not	bored	she	they	Love
feel			it	do not	

4.3.1. List of target words

The target words included in the mental states lessons include emotions, emotions verbs, non-emotional psychological states adjectives, mental states verbs, pronouns and negation (i.e., '*do not')*. The reason for the inclusion of the last two categories was that these are important words in the context of mental states. In order to properly use the mental states words it is important to know who has the mental state that one is referring to. That is, it is important to know who is, for example 'happy'. Pronouns are used to refer to the agent who experiences the mental state. In addition, it is also important to know what mental state is not being experienced by someone. For example, it is important to know that someone does not know something. Therefore, the negation form is also important in this context. Table 5 lists the target words and shows in which lesson and session these are provided. The distribution of words over the sessions is such that words and concepts become more difficult as the child proceeds through the lesson series. The difficulty level of the words was determined according to log frequency counts and corpora and the Age of Acquisition lists (see section 2.2). In the mental states domain we have included fewer target words than in the other two domains, since mental state vocabulary is generally more complex than math and spatial vocabulary and involves rather subtle differences in meaning (e.g., "want" vs. "need"), so children are likely to need exposure to more instances of each word.

4.3.2 List of activities

As mentioned in the previous domains, we chose several locations and games for the children that provide a meaningful context to learn the target words. The following table shows an overview of the lessons and sessions and the activities that are presented in each session. The settings are all part of a town that the robot and the child are exploring together. The setting of the town is used across all three domains.

Table 6.
Setting and activities per lesson in the mental states domain.

Lesson	**Session**	**Setting**	**Activity**	**Example tasks**
Lesson 1	Session 1	Hospital	Treating patients	Giving medicine to a child to make him or her better, so that the child is no longer sad. Giving a teddy bear to a sad child to make him or her happy.
Lesson 1	Session 2	Toy store	Find a present for child	Turning on a toy that makes a child laugh. Saying do *not* touch to customers in the toy shop.
Lesson 1	Session 3	Daycare	Taking care of baby	Feeding the baby when it is hungry. Putting the baby to bed when it is tired.
Lesson 2	Session 1	Library	Reading a book about friendly ghosts	Listening to the robot reading a child-friendly picture book. Answering questions while going through the book.
Lesson 2	Session 2	Pet Shop	Playing with animals	Playing with various animals in the pet shop.
Lesson 2	Session 3	Supermarket	Shopping	Purchasing food at the supermarket.

5 Conclusion

5.1 Completion of targets

In the past year major steps have been taken towards the design of a lessons series that can be used in the L2TOR project. The first target that has been obtained is the conceptual definition of the three content domains, and identification and selection of appropriate target words to be used in the lessons (see section 2, lessons development). In addition, decisions were made regarding issues such as the role of the robot, the role of the tablet, the reward system used, and the locations where the lessons take place. These decisions were based on pilot testing and literature reviews, and were made in close collaboration with all other partners in the consortium.

Based on these steps, a framework has been created in which the lessons can easily further be developed. Several lessons have already been scripted in detail and these lessons will function as a basis for further lesson development in collaboration with other work packages (see section 5.3).

5.2 Challenges faced in design of the lessons series

During the process of lesson development, we have encountered a few challenges regarding the content of the lessons and the capabilities of the robot. Below we discuss these challenges.

5.2.1 Challenges regarding the content of the lessons

The target words belonging to the domains chosen for L2TOR are mainly adjectives, verbs, prepositions, and pronouns. Not many nouns are included in the lessons as target words, as the main words to be taught within the domains chosen for L2TOR include mainly adjectives (maths and mental states domain), prepositions (space domain), verbs (all three domains) and pronouns (mental states domain). Especially for children with little knowledge of L2, this might be challenging. Nouns might be easier to learn as first words in a foreign language. However, as the target words are expected to be familiar words in the children's first language, we expect the children to be able to learn them. A second challenge was the fact that children with no knowledge of L2 learned very little in our pilot study (see section 2.3.2). We have tried to solve this problem by decreasing the number of target words and increasing the number of repetitions. In the coming months, WP5 will conduct experiments to determine the number of repetitions and explore the possibility of determining the number of repetitions dynamically, based on the child's progress. In the future, we also need to conduct pilot work with children with more knowledge of L2 (e.g., Turkish immigrants in the Netherlands) to determine the amount of L1 input required for these children to learn the target words in L2.

5.2.2 Challenges regarding working with the robot

There were a few issues with respect to the robot that made the design of the L2 teaching sessions more challenging than anticipated. The first is that automatic speech recognition of child speech turned out to be very difficult, and thus cannot be relied on for the moment. Without a functioning automatic speech-recognition system it becomes difficult for the robot to monitor the child's linguistic errors, which is a clear drawback. To

solve this issue, while SoftBank Robotics works on resolving these issues, we decided to rely on a tablet screen in all lessons that functions as an intermediate device through which the robot and the child can communicate. Moreover, even if speech recognition will eventually not be possible, we will still be able to make use of sound detection in our lesson series, to recognize whether the child is saying something and have the robot respond accordingly (e.g., redirect the focus of the child to the tablet).

A second limitation is that the robot is not very well capable of perceiving visual input and understanding the non-verbal signals produced by the child, in particular, the child's gestures. Again, this will be dealt with by stimulating children to touch pictures on the tablet rather than produce communicative gestures, such that the robot can process them and react to them. In addition, we are exploring other solutions to this problem involving the use of sensors (e.g., Kinect) to detect non-verbal signals provided by the child.

A final limitation concerns the perception and manipulation abilities of the robot. These limitations are inherent to the robotic platform chosen for the project and will not be addressable within the scope of the project. We are currently investigating whether children's manipulation of real objects benefits children's learning. If the use of real objects turns out to be more beneficial than virtual 3D representations of objects depicted on a tablet screen, the use of extra sensors (e.g., Kinect) and QR codes or so called 'smart toys' will be explored as possible means for the robot to perceive objects in the real world.

5.3 Further steps in lesson development

Based on the conclusions drawn during the pilot testing and the process of lessons development, some adjustments have been made to the lessons series resulting in the framework described in this document. The scripts provided in this document (see Appendix 2) and framework described here are merely a draft version. In the next stages of the project the framework and the scripts will be studied carefully by other work packages and be finalized in collaboration with them. The steps to be taken include translating the lessons into specifications of interactions between the L2TOR robot, the child, and the tablet display (WP 2); working on the adaptivity of the lessons (in collaboration with WP5, see also section 3.7); deciding on the amount of L1/L2 input to be used for the different groups (in collaboration with WP 6 and other partners); deciding on the use of real-life objects, and if we decide to use them, how to incorporate them into the lessons (in collaboration with WP 4). During all these steps, the lessons will be adapted accordingly. This ongoing process of lessons development will ultimately lead to the final version to be used in the evaluation study (WP 7).

References

Barcelona European Council, 15 and 16 March 2002, Presidency Conclusions, part I, 43.1.

Birchenough, J.M.H., Davies, R., & Connelly, V. (2016). Rated age-of-acquisition norms for over 3,200 German words. *Behavior Research Methods,* Advanced online publication. doi: 10.3758/s13428-016-0718-0

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647-63.

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational researcher*, 4-16.

Brysbaert, M., & Ghyselinck, M. (2006). The effect of age of acquisition: Partly frequency related, partly frequency independent. *Visual Cognition, 13*(7-8), 992-1011.

Brysbaert, M., Stevens, M., De Deyne, S., Voorspoels, W., & Storms, G. (2014). Norms of age of acquisition and concreteness for 30,000 Dutch words. *Acta Psychologica, 150,* 80-84.

Brühwiler, C., & Blatchford, P. (2011). Effects of class size and adaptive teaching competency on classroom processes and academic outcome. *Learning and Instruction, 21(1),* 95-108.

Buijs, K., Klep, J., & Noteboom, A. (2008). Tussendoelen en leerlijnen: Rekenen/wiskunde [Goals and educational curriculum: Numeracy / Maths]. Enschede, The Netherlands: SLO.

De Feyter, J. J., & Winsler, A. (2009). The early developmental competencies and school readiness of low-income, immigrant children: Influences of generation, race/ethnicity, and national origins. *Early Childhood Research Quarterly, 24(4),*11-431.

De Mulder, H.L.N.M. (2011). *Putting the pieces together: The development of theory of mind and (mental) language* (Doctoral dissertation). Utrecht, the Netherlands: LOT.

De Villiers, J. (2007). The interface of language and theory of mind. *Lingua, 117,* 1858-1878. doi: 10.1016/j.lingua.2006.11.006

Dunn, L.M., & Dunn,L.M. (1997). *Peabody Picture Vocabulary Test-III.* San Antonio, TX: Pearson. Harcourt.

Dunn, L.M., & Dunn,L.M. (2005). *Peabody Picture Vocabulary Test-III-NL handleiding* (L.SchlichtingTrans.). Amsterdam, The Netherlands: Harcourt.

Eurostat (2016). Foreign language learning statistics. Retrieved December 13: from ec.europa.eu/eurostat/statistics-explained/index.php/Foreign_language_learning_statistics

Glenberg, A.M. (2008). Embodiment for education. In: P. Calvo, & T. Gomila (Eds.). Handbook of Cognitive science: An embodied approach. Amsterdam, The Netherlands: Elsevier.

Göz, I., Tekcan, A.I., Erciyes, A.A. (2016). Subjective age-of-acquisition norms for 600 Turkish words from four age groups. *Behavior Research Methods,* Advanced online publication. doi: 10.3758/s13428-016-0817-y

Han, J., Jo, M., Park, S., and Kim, S. (2005). The educational use of home robots for children. In Proceedings of the 14th IEEE International Symposium on Robots and Human Interactive Communications, ROMAN 2005, pages 378-383. IEEE.

Hegarty, M., Keehner, M., Khooshabeh, P., & Montello, D. R. (2009). How spatial abilities enhance, and are enhanced by, dental education. *Learning and Individual Differences, 19*, 61–70.

Hoff, E. (2013). Interpreting the Early Language Trajectories of Children from Low SES and Language Minority Homes: Implications for Closing Achievement Gaps. *Developmental Psychology, 49(1),* 4–14.

Hockema, S. A., & Smith, L. B. (2009). Learning your language, outside-in and inside-out. Linguistics, 47, 453-479. doi:10.1515/LING.2009.016

Hyun, E., Kim, S., Jang, S., and Park, S. (2008). Comparative study of effects of language instruction program using intelligence robot and multimedia on linguistic ability of young children. In Proceedings of the 17th IEEE International Symposium on Robots and Human Interactive Communications, RO-MAN 2008, pages 187-192. IEEE.

Johnson, W. L. (2010). Serious use of a serious game for language learning. International Journal of Artificial Intelligence in Education, 20(2):175-195.

Johnston, J. R., & Slobin, D. I. (2008). The development of locative expressions in English, Italian, Serbo-Croatian and Turkish. *Journal of Child Language*, *6*(3), 529-545. doi: 10.1017/S030500090000252X

Kim, Y. K., Curby, T. W., & Winsler, A. (2014). Child, family, and school characteristics related to English proficiency development among low-income, dual language learners. *Developmental Psychology*, *50*, 2600.

Kennedy, J., Baxter, P., and Belpaeme, T. (2014b). Children comply with a robot's indirect requests. In Proceedings of the 9th ACM/IEEE International Conference on Human-Robot Interaction, pages 198-199. ACM.

Kennedy, J., Lemaignan, S., Montassier, C., Lavalade, P., Irfan, B., Papadopoulos, F., Senft, E., Belpaeme, T. (in press). Child speech recognition in human-robot interaction: Evaluations and recommendations. In: Proceedings of the 2017 ACM/IEEE International Conference on Human-Robot Interaction.

Kersten, A.W., & Smith, L.B. (2002). Attention to novel objects during verb learning. Child Development, 73, 93-109.

Kose-Bagci, H., Ferrari, E., Dautenhahn, K., Syrdal, D. S., and Nehaniv, C. L. (2009). Effects of embodiment and gestures on social interaction in drumming games with a humanoid robot. *Advanced Robotics,23* 1951-1996.

Kozhevnikov, M., Motes, M. A., & Hegarty, M. (2007). Spatial visualization in physics problem solving. *Cognitive Science*, *31*, 549–579.

Kuperman, V., Stadthagen-Gonzalez, H., & Brysbaert, M. (2012). Age-of-acquisition ratings for 30,000 English words. *Behavior Research Methods, 44*, 978-990. doi:10.3758/s13428-012-0210-4

Leseman, P. P., & van den Boom, D. C. (1999). Effects of quantity and quality of home proximal processes on Dutch, Surinamese–Dutch and Turkish–Dutch preschoolers' cognitive development. *Infant and Child Development, 8*, 19-38.

Leyzberg, D., Spaulding, S., Toneva, M., and Scassellati, B. (2012). The physical presence of a robot tutor increases cognitive learning gains. In *Proceedings of the 34th Annual Conference of the Cognitive Science Society, CogSci 2012*, pages 1882-1887.

Mahone, E. M., & Schneider, H. E. (2012). Assessment of Attention in Preschoolers. *Neuropsychology Review*, *22*(4), 361–383. Marulis, L. M., & Neuman, S. B. (2010). The effects of vocabulary intervention on young children's word learning a meta-analysis. Review of educational research, 80(3), 300-335.

National Reading Panel. (2000). Teaching children to read. Washington, DC: National Institute of Child Health and Development.

Oudgenoeg-Paz, O., Leseman, P.P.M., & Volman, M.C. (2015). Exploration as a mediator of the relation between the attainment of motor milestones and the development of spatial cognition and spatial language. *Developmental Psychology, 51,* 1241-1253. doi: 10.1037/a0039572

Pruden, S. M., Levine, S. C., & Huttenlocher, J. (2011). Children's spatial thinking: does talk about the spatial world matter? *Developmental Science*, *14*(6), 1417-30. doi: 10.1111/j.1467-7687.2011.01088.x.

Reich-Stiebert, N., & Eyssel, F. (2016). Robots in the classroom: What teachers think about teaching and learning with education robots. In A. Agah, J. Cabibihan, A. M. Howard, M. A. Salichs, & H. He (Eds.), *Social robotics* (pp. 671-680). Switzerland: Springer International Publishing.

Ryokai, K., Vaucelle, C., & Cassell, J. (2003). Virtual peers as partners in storytelling and literacy learning. *Journal of Computer Assisted Learning*, *19*(2), 195-208.

Schlichting, J.E.P.T., & Lutje Spelberg, H.C. (2002). *Lexilijst Nederlands* [Dutch lexicon lists]. Amsterdam, The Netherlands: Pearson.

Schweers, W. Jr. (1999). Using L1 in the L2 classroom. *English Teaching Forum*, *37*, 6–9.

Scot, V. M. & de la Fuente, M. J. (2008). What"s the Problem? L2 Learners" Use of the L1 during consciousness-raising, form-focused tasks. *The Modern Language Journal*, *92*, 100-113.

Shatz, M., Weliman, H.M., & Silber, S. (1983). The acquisition of mental verbs: A systematic investigation of the first reference to mental states. *Cognition, 14,* 301-321.

Trofimovich, P., & Gatbonton, E. (2006). Repetition and focus on form in processing L2 Spanish words: Implications for pronunciation instruction. The Modern Language Journal, 90(4), 519-535.

Van der Hoeven-van Doornum, A. (2005). *Development on scale, instruction at measure: OBIS, a system of value added indicators in primary education.* Nijmegen, The Netherlands: ITS, Radboud University.

Van Kuyk, J.J. (1992). *Leerling volg ordenen, groep 1-2* [Standard test for kindergarten early numeracy]. Arnhem, The Netherlands: CITO.

Van Kuyk, J.J. (1996a). *Leerling volg systeem ruimte en tijd, groep 1-2* [Standard test for kindergarten space and time]. Arnhem, The Netherlands: CITO.

Van Kuyk, J.J. (1996b). *Leerling volg systeem taal voor kleuters* [Standard test for kindergarten language]. Arnhem, The Netherlands: CITO.

VanLehn, K. (2011) The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist,* 46(4):197-221.

Van Luit, J. E. H., & Van de Rijt, B. A. M. (2009). *Utrechtse getalbegrip toets - revised* [Early numeracy test - revised]. Doetinchem, The Netherlands: Graviant.

Van Luit, J. E. H., & Toll, S. W. M. (2013). *Op weg naar rekenen. Remediërend programma voor kleuterrekenen* [The road to mathematics. Remedial program for early numeracy]. Doetinchem, The Netherlands: Graviant.

Wanzel, K. R., Hamstra, S. J., Anastakis, D. J., Matsumoto, E. D., & Cusimano, M. D. (2002). Effect of visual-spatial ability on learning of spatially-complex surgical skills. *The Lancet*, *359*(9302), 230–231.

Zaga, C., Lohse, M., Truong, K. P., & Evers, V. (2015). The Effect of a Robot's Social Character on Children's Task Engagement: Peer Versus Tutor. *International Conference on Social Robotics*, 704-713.

Zink, I., & Lejaegere, M. (2002). *N-CDIs: Lijsten voor communicatieve ontwikkeling* [N-CDIs: Lists for communicative development]. Leuven, Belgium: Acco.

Appendix 1: Corpora

Below is a list of the corpora used to check the log frequency counts of the chosen words. The list is divided in sources for written adults language, spoken adult language, written children's language and spoken children's language. Where appropriate, links are provided. For each corups or group of corpora we indicate for the words of which domain they were used.

Written Dutch- Adults (used for spatial domain)

- Parole – 2004 (Centre for language and speech technology [TST centrale], 2012)
- 5 million words - 1994 (Centre for language and speech technology [TST centrale], 2012)
- 27 million words – 1995 (Centre for language and speech technology [TST centrale], 2012)
- 38 million words -1996 (Centre for language and speech technology [TST centrale], 2012)

(for all of the above corpora see: see: http://tst-centrale.org/nl/producten/lexica/frequentielijsten-corpora/7-51).

- General Dutch Dictionary [Algemene Nederlands Woordenboekcorpus] (INL, 2009) (see: http://anw.inl.nl/search)
- CELEX (Max Planck Institute for Psycholinguistic, 2001) (see: http://celex.mpi.nl/)

Spoken Dutch adults (used for spatial and mental states domains)

- Corpus of spoken Dutch [Corpus Gesproken Nederlands] (Nederlandse Taalunie, 2004) (see: http://lands.let.ru.nl/cgn/)

Written Dutch for children

- Children's book corups (Messer, Leseman, Boom, & Mayo, 2010) (used for spatial domain)
- Basilex (Tellings, Hulsbosch, Vermeer, & van den Bosch, 2014) (used for maths and mental states domains).

Spoken Dutch – children (used for spatial domain).

- CHILDES data (Bol, 1995; De Houwer, 2003; MacWhinney, 2000; Ruhland, Wijnen, & van Geert, 1995; van Kampen, 1994; Wijnen, 1988).

References

Bol, G. W. (1995). *Implicational scaling in child language acquisition: The order of production of Dutch verb constructions*. In M. Verrips, & F. Wijnen (Eds.), Papers from the Dutch–German colloquium on language acquisition. Amsterdam series in child language development (pp.1–13). Amsterdam, The Netherlands: Institute for General Linguistics.

Centre for language and speech technology [TST Centrale]. (2012). *Frequency lists corpora* [Frequentielijsten corpora]. The Hague, The Netherlands: The Dutch

Language Union. http://tst-centrale.org/nl/producten/lexica/frequentielijsten-corpora/7-51

De Houwer, A. (2003). Language variation and local elements in family discourse. *Language Variation and Change*, 15, 327–347. doi:10.1017/S0954394503153033

Dutch Language Union [Nederlandse Taalunie]. (2004). *Corpus of spoken Dutch* [Corpus Gesproken Nederlands]. The Hague, The Netherlands: Nederlandse Taalunie. http://lands.let.ru.nl/cgn/

Institute for Dutch Lexicology [Instituut voor Nederlandse Lexicologie – INL]. (2009). *General Dutch dictionary* corpus [Algemene Nederlands Woordenboekcorpus]. Leiden, The Netherlands: INL. http://anw.inl.nl

MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk* (3rd ed.). Mahwah, NJ: Erlbaum.

Max Planck Institute for Psycholinguistic. (2001). *CELEX*. Nijmegen, the Netherlands: MPI. http://celex.mpi.nl/

Messer, M. H., Leseman, P. P. M., Boom, J., & Mayo, A. Y. (2010). Phonotactic probability effect in nonword recall and its relationship with vocabulary in monolingual and bilingual preschoolers. *Journal of Experimental Child Psychology, 105*, 306–323. doi: 10.1016/j.jecp.2009.12.006

Ruhland, R., Wijnen, F., & van Geert, P. (1995). *An exploration into the application of dynamic systems modelling to language acquisition*. In M. Verrips & F. Wijnen (Eds.), Amsterdam series in child language acquisition: Vol. 4. Approaches to parameter setting (pp. 107–134). Amsterdam, The Netherlands: Institute for General Linguistics.

Tellings, A., Hulsbosch, M., Vermeer, A., & van den Bosch, A. (2014). BasiLex: an 11.5 million words corpus of Dutch texts written for children. *Computational Linguistics in the Netherlands Journal, 4*, 191-208.

van Kampen, N. J. (1994). The learnability of the left-branch condition. Linguistics in the Netherlands, 11, 83–94. doi: 10.1075/avt.11.10kam

Wijnen, F. (1988). Spontaneous word fragmentation in children: Evidence for the syllable as a unit in speech production. *Journal of Phonetics, 16*, 187–202.

Appendix 2: Sample lessons for each domain

1. Math Domain

LESSON 1 – QUANTITIES

Participants: Child, Robot
Lesson program: Introduction to quantities
Setting: Zoo
Game: Putting the animals into the cage

Text said in English is indicated in *italics*. Rest of text is said in L1.

Target words: One, two, three, more, add
Support words: Elephant, giraffe

Introduction: about 2 minutes
Robot: Hello… (name of child). Let's play together! Do you like games?
Child: (probably yes, answer doesn't really matter)
Robot: I really like games! Look, we will visit a new place today. Look where we're going today!
(Robot "touches" tablet and the screen displays the town. The robot and child avatars are walking towards the zoo.)
Robot: Cool, today we'll visit the zoo! I really like animals. Do you also like animals?
Child: (probably yes, answer doesn't really matter)
Robot: Touch the zoo and we will enter it!
→ Child touches the zoo.

- In case of correct response, the zoo is entered.
- If the child touches something else, the robot says 'no that wasn't the zoo, touch the zoo'
- If the child says something, the robot says 'can you touch the zoo on the tablet'
- If nothing happens, the robot says 'do you see the zoo? Touch it on the tablet!'
  - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the zoo. You can also do that!'

Modelling of words: about 10 minutes
(Tablet displays new screen with 2 elephants and a cage.)
Robot: Cool, they are elephants! Touch them and we'll hear the English word for elephant.
→ Child touches elephant.

- In case of correct response, tablet says '*elephant'*
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch it on the tablet'

- If nothing happens, the robot says ‘do you see the elephant? Touch it on the tablet!’
    - If still nothing happens, the robot shows the child how to do it: ‘it was the elephant! Look, I’m touching the elephant.’

Robot: Ah, an elephant is in English an e*lephant.* Can you also say *elephant*?
Child: *Elephant.*

- If the child says *elephant* or something else, the robot says ‘good job, *elephant*!’
- If the child does not say anything, the robot says ‘I know you can do it, say it just like I do: *elephant’*
    - If the child still doesn’t say anything, the robot says ‘it was *elephant,* let’s see what we have to do now’

Robot: Now, I think there’s a very important task for us! The elephants are loose and we have to put them in their cage! Put the *elephant* in its cage.
(A helpful arrow appears on the screen.)
→ Child drags elephant to cage.

- In case of correct response, robot says ‘good job!’ and the elephant makes a happy elephant sound, and the child and the robot receive a star
- If the child touches the elephant but does not drag it to the cage, robot says ‘very good, that’s the *elephant*, now drag it to the cage’
- If the child doesn’t do anything/touches the tablet randomly, the robot says ‘let’s put the elephant in its cage!
    - Still nothing: the robot says ‘let me show you how to do it’ and “drags” the elephant to its cage, while saying ‘I’m putting the elephant in its cage’

Robot: Now we have one *elephant* in the cage. Let’s hear what one is in English. Can you touch the *elephant* in the cage?
→ Child touches elephant.

- In case of correct response, tablet says ‘*one elephant’*
- If the child touches something else, the robot says ‘no that wasn’t it, touch the one elephant in the cage’
- If the child says something, the robot says ‘touch it on the tablet’
- If nothing happens, the robot says ‘do you see the one elephant in its cage? Touch it on the tablet!’
    - If still nothing happens, the robot shows the child how to do it: ‘it was the elephant! Look, I’m touching the elephant.’

Robot: So one is *one.* Say *one.*
Child: *One.*

- If the child says *one* or something else, the robot says: ‘good job, ‘*one’*!
- If the child does not say anything, the robot says: ‘say *one’*
    - If the child still doesn’t say anything, the robot says ‘it was *one,* let’s see what we have to do now’

Robot: So there’s *one elephant*. But there’s still *one elephant* outside of the cage. We will add *one elephant* to the cage, add *one elephant* to the cage and we’ll hear what add is.
(A helpful arrow appears on the screen again.)
→ Child drags elephant to cage. While dragging the tablet says ‘*add’* and the robot says ‘*add,* say *add*’ (note, the images of the elephants automatically slightly overlap when

placed in the cage, so that later the child naturally touches both elephants. In fact they form one object on the tablet consisting of two elephants).

- In case of correct response, robot says 'good job!' and the elephant makes a happy elephant sound, and the child and the robot receive a star
  - If the child says '*add'* or something else, the robot says 'yes, *add'*
  - If the child does not say anything, the robot says: 'say *add'*
    - If the child still doesn't say anything, the robot says 'it was *add,* let's see what we have to do now'
- If the child touches the elephant but does not drag it to the cage, robot says 'very good, that's the *elephant*, now drag it to the cage'
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the elephant in its cage!
  - Still nothing: the robot says 'let me show you how to do it' and "drags" the elephant to its cage, while saying 'I'm putting the elephant in its cage' While dragging the tablet says '*add'* and the robot says '*add,* say *add*'
- In case of correct response, robot says 'good job!' and the elephant makes a happy elephant sound, and the child and the robot receive a star
  - If the child says '*add'* or something else, the robot says 'yes, *add'*
  - If the child does not say anything, the robot says: 'say *add'*
    - If the child still doesn't say anything, the robot says 'it was *add,* let's see what we have to do now'

Robot: Now there are two elephants in the cage! Touch them, then we'll hear what two is.
→ Child touches the elephants.

- In case of correct response, tablet says '*two'* and the robot says '*two,* say *two'*
  - If the child says *two* or something else, the robot says: 'good job, *two elephants*!'
  - If the child does not say anything, the robot says: 'say *two'*
    - If the child still doesn't say anything, the robot says 'it was *two,* let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the elephants on the tablet'
- If nothing happens, the robot says 'touch the elephants on the tablet!'
  - If still nothing happens, the robot shows the child how to do it: 'I will show you how to do it'

Robot: Great, we have *two elephants* in the cage! Now, let's go to the next cage.
(Robot "touches" tablet. Tablet displays a new screen with the 2 elephants in their cage, 3 loose giraffes and another cage.)
Robot: Cool, now we have *two elephants* and three giraffes! Let's see what that is in English. Touch the giraffe and let's find out.
→ Child touches the giraffe.

- In case of correct response, tablet says '*giraffe'* and the robot says '*giraffe'*
  - If the child says '*giraffe'* or something else, the robot says: 'good job, *giraffe*!'
  - If the child does not say anything, the robot says: 'say *giraffe'*

        - If the child still doesn't say anything, the robot says 'it was *giraffe,* let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the giraffes on the tablet'
- If nothing happens, the robot says 'touch the giraffes on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'I will show you how to do it'

Robot: Look at this, we have another important task. Let's put the *giraffe* in its cage!
(A helpful arrow appears on the screen.)
→ Child drags the giraffe to the cage. While dragging the tablet says '*add'*

- In case of correct response, robot says '*add,* that was add, good job!' and the giraffe makes a happy sound, and the child and the robot receive a star
- If the child touches the giraffe but does not drag it to the cage, robot says 'very good, that's the *giraffe*, now drag it to the cage'
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the giraffe in its cage!
    - Still nothing: the robot says 'let me show you how to do it' and "drags" the giraffe to its cage, while saying 'I'm putting the giraffe in its cage'

Robot: One of the cages has more animals. Touch the cage with more animals than the other, and we'll hear the English word for more.
→ Child touches the cage with elephants.

- In case of correct response, tablet says '*more'* and robot says '*more*, say *more'*
    - If the child says '*more'* or something else, the robot says: 'good job, *more*!'
    - If the child does not say anything, the robot says: 'say *more'*
        - If the child still doesn't say anything, the robot says 'it was *more,* let's see what we have to do now'
- If the child touches the giraffe cage, the robot says 'no that wasn't it, touch the cage that has more animals than the other'
- If the child says something, the robot says 'can you touch it on the tablet'
- If nothing happens, the robot says 'do you see the cage with more animals? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'it was the cage with the elephants! Look, I'm touching the cage with the elephants.'

Robot: There are still *two giraffes* outside of the cage. Can you *add one more giraffe* to the cage?
(A helpful arrow appears on the screen.)
→ Child drags the giraffe to the cage. While dragging the tablet says '*add'*

- In case of correct response, robot says 'good job!' and the giraffe makes a happy sound, and the child and the robot receive a star
- If the child touches the giraffe but does not drag it to the cage, robot says 'very good, that's the *giraffe*, now drag it to the cage'
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the giraffe in its cage!

Robot: Now there are *two giraffes*. Now there are *more giraffes* inside the cage than outside the cage. Can you *add one more giraffe?*
(A helpful arrow appears on the screen.)

→ Child drags the giraffe to the cage. While dragging the tablet says '*add'*

- In case of correct response, robot says 'good job!' and the giraffe makes a happy sound, and the child and the robot receive a star
- If the child touches the giraffe but does not drag it to the cage, robot says 'very good, that's the *giraffe*, now drag it to the cage'
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the giraffe in its cage!

Robot: Now there are three giraffes! Touch them, then we'll hear what three is?
→ Child touches the giraffes.

- In case of correct response, tablet says '*three elephants'* and the robot says '*three,* say *three'*
    - If the child says *three* or something else, the robot says: 'good job, *three giraffes*!'
    - If the child does not say anything, the robot says: 'say *three'*
        - If the child still doesn't say anything, the robot says 'it was *three,* let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the giraffes on the tablet'
- If nothing happens, the robot says 'touch the giraffes on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'I will show you how to do it'

Robot: You did an awesome job, the *two elephants* and the *three giraffes* are back in their cage! In which cage are there *more* animals? Touch the cage that has *more* animals in it.
→ Child touches the cage with giraffes.

- If the child touches the giraffe cage, the tablet says '*more'* and the robot says 'good job, that cage has *more* animals!'
- If the child says something, the robot says 'can you touch it on the tablet'
- If nothing happens, the robot says 'do you see the cage with more animals? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'it was the cage with the giraffes! Look, I'm touching the cage with the giraffes.'

Robot: Great! Look, there are some trees over there. Let's put them in the cage so the giraffes can eat from them. We have *three* giraffes so we need *three* trees. Can you *add* the trees to the cage? Count them while dragging
→ Child drags the trees to the cage.

- In case of correct response, robot says 'good job!' and the giraffes make a happy sound, and the child and the robot receive a star
    - When the child drags a tree, the robot counts with the child: *one, two, three*. It doesn't really matter whether the child will say it or not, at least the robot will provide extra input.
- If the child touches the tree but does not drag it to the cage, robot says 'very good, that's the tree, now drag it to the cage'
- If the child drags one tree to the cage and then stops, the robot says 'very good, that was one tree, now also put the two other trees in the cage'
- If the child drags two trees to the cage and then stops, the robot says 'very good, now also drag the last one to the cage'

- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the trees in the cage!

Robot: Great! Now each giraffe has their own tree, because there are *three* giraffes and *three* trees! You did great, now let's play another game!
(Robot "touches" tablet. Tablet starts task 1.)

Task: about 5 minutes
(Tablet displays a new screen with 5 giraffes in their cage and a lake next to the cage.)
Robot: Look! There are some *giraffes* in the cage, but today the weather is very nice and they're going to swim in the lake! Put *one giraffe* in the lake.
→ Child puts one giraffe in the lake.

- In case of correct response, robot says 'good job!' and the giraffe makes a happy sound (maybe also like confetti or something else festive)
- If the child touches the giraffe but does not drag it to the lake, robot says 'very good, that's the *giraffe*, now drag it to the lake
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the giraffe in its lake!
    - Still nothing: the robot says 'let me show you how to do it' and "drags" the giraffe to its lake, while saying 'I'm putting the giraffe in the lake'

Robot: Can you *add two giraffes* to the lake?
→ Child puts one giraffe in the lake.

- Similar response scenario's

Robot: Where are *two giraffes?* Touch the area on the tablet.

- If the child touches the cage, the robot says 'good job!'
- If the child touches the lake, the robot says 'no, there are too many giraffes there. Where are *two giraffes?'*
    - If still wrong, the robot says 'there are *two giraffes* in the cage!'

Robot: Where are *three giraffes?* Touch the area on the tablet.

- Similar response scenario's.

Robot: Where are *more giraffes*, in the cage of the lake? Touch the area on the tablet.

- If the child touches the cage, the robot says 'good job!'
- If the child touches the lake, the robot says 'no, there are fewer giraffes in the lake than in the cage. Where are *more giraffes?'*
    - If still wrong, the robot says 'there are *more giraffes* in the cage!'

End of lesson
(On the tablet, the 'home screen' with the town and the avatars pops back up again. The child and the robot receive a big star for their work, in a festive animation.)
Robot: Yay we got a star! It was very nice to play with you! Bye!

LESSON 1 – SESSION 2

Participants: Child, Robot
Lesson programme: Larger quantities
Setting: Flower shop
Game: Making bouquets

Text said in English is indicated in *Italics*. Rest of text is said in L1.

Target words: Four, five, six, seven, fewer, take away
Support words: Flowers, bucket
Implicit support words: Is, than

Introduction: about 1 minute
Robot: Hello… (name of child). I really liked playing with you last time! Did you also like to play last time?
Child: (yes or no)
Robot: Today we'll play another game, because we're going to a different part of the town! Let's see where we're going today! Touch the tablet to begin.
(Child touches tablet. The screen displays the town and the robot and child avatars are walking towards the flower shop.)
Robot: Cool, today we're going to help in the flower shop! Touch the tablet to begin!
(Child touches tablet. Tablet displays the inside of the flower shop.)

Modelling of words: about 12 minutes
Robot: Wow, there are so many flowers! Touch the flowers to hear the English word for flowers.
→ Child touches flowers.

- In case of correct response, tablet says '*flowers'*
- If the child touches something else, the robot says 'no that wasn't it, try again, touch the flowers'
- If the child says something, the robot says 'touch the flowers on the tablet'
- If nothing happens, the robot says 'do you see the blue flowers? Touch them on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the flowers.'

Robot: Ah, in English flowers are *flowers.* Can you also say *flowers*?
Child: *Flowers.*

- If the child says *flowers* or something else, the robot says 'good job, *flowers*!'
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *flowers'*
    - If the child still doesn't say anything, the robot says 'it was *flowers,* let's see what we have to do now'

Robot: Look, there are a lot of empty vases. I think we have to fill them with flowers! Touch the orange vase and we'll hear what to do.
→ Child touches orange vase.

- In case of correct response, tablet says '*add three flowers'*
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the orange vase on the tablet'
- If nothing happens, the robot says 'do you see the orange vase? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the orange vase.'

Robot: Cool! Can you *add three flowers*¸ so add three flowers?
(A helpful arrow appears on the screen.)
→ Child drags three flowers to the vase, one at the time. While dragging the tablet counts *'one, two, three'*

- In case of correct response, robot says 'good job!' and the tablet makes a happy sound, and the child and the robot receive a star
- If the child touches the flower but does not drag it to the vase, robot says 'very good, that's the flower, now drag it to the vase'
- If the child drags one flower to the vase and then stops, the robot says 'very good, that was one flower, now also put the two other flowers in the vase'
- If the child drags two flowers to the vase and then stops, the robot says 'very good, now also drag the last one to the vase'
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the flowers in the vase!

Robot: There's still room for another flower! Let's *add one flower*.
(A helpful arrow appears on the screen.)
→ Child adds another flower.

- In case of correct response, robot says 'yay' and the tablet makes a happy sound, and the child and the robot receive a star
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'put another flower in the vase on the tablet'
- If nothing happens, the robot says 'put another flower in the vase on the tablet'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm putting another flower in the vase.'

Robot: Cool, now we have four flowers in the vase! Touch the vase to hear the English word for four.
→ Child touches flowers.

- In case of correct response, tablet says '*four'* and the robot says '*four, say four'*
    - If the child says *four* or something else, the robot says: 'good job, *four flowers*!'
    - If the child does not say anything, the robot says: 'say *four'*
        - If the child still doesn't say anything, the robot says 'it was *four,* let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the orange vase on the tablet'
- If nothing happens, the robot says 'do you see the orange vase? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the orange vase.'

Robot: Great! Now, let's fill the other vase. Touch the green vase and we'll hear what to do.
→ Child touches green vase.

- In case of correct response, tablet says '*add four flowers'*
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the green vase on the tablet'

- If nothing happens, the robot says ‘do you see the green vase? Touch it on the tablet!’
    - If still nothing happens, the robot shows the child how to do it: ‘Look, I’m touching the green vase.’

Robot: Cool! Can you *add four flowers?*
(A helpful arrow appears on the screen.)
→ Child drags four flowers to the vase, one at a time. While dragging the tablet counts *‘one, two, three, four’*

- In case of correct response, robot says ‘good job!’ and the tablet makes a happy sound, and the child and the robot receive a star
- If the child touches the flower but does not drag it to the vase, robot says ‘very good, that’s the flower, now drag it to the vase’
- If the child drags one flower to the vase and then stops, the robot says ‘very good, that was one flower, now also put three more flowers in the vase’
- If the child drags two flowers to the vase and then stops, the robot says ‘very good, now also drag two more flowers to the vase’
- If the child drags three flowers to the vase and then stops, the robot says ‘very good, now also drag the last one to the vase’
- If the child doesn’t do anything/touches the tablet randomly, the robot says ‘let’s put the flowers in the vase!

Robot: There’s still room for another flower! Let’s *add one flower*.
(A helpful arrow appears on the screen.)
→ Child adds another flower.

- In case of correct response, robot says ‘yay’ and the tablet makes a happy sound, and the child and the robot receive a star
- If the child touches something else, the robot says ‘no that wasn’t it, try again’
- If the child says something, the robot says ‘put another flower in the vase on the tablet’
- If nothing happens, the robot says ‘put another flower in the vase on the tablet’
    - If still nothing happens, the robot shows the child how to do it: ‘Look, I’m putting another flower in the vase.’

Robot: Cool, now we have five flowers in the vase! Touch the vase to hear the English word for five.
→ Child touches vase.

- In case of correct response, tablet says ‘*five’* and the robot says ‘*five, say five’*
    - If the child says *five* or something else, the robot says: ‘good job, *five flowers*!’
    - If the child does not say anything, the robot says: ‘say *five’*
        - If the child still doesn’t say anything, the robot says ‘it was *five*, let’s see what we have to do now’
- If the child touches something else, the robot says ‘no that wasn’t it, try again’
- If the child says something, the robot says ‘touch the green vase on the tablet’
- If nothing happens, the robot says ‘do you see the green vase? Touch it on the tablet!’
    - If still nothing happens, the robot shows the child how to do it: ‘Look, I’m touching the green vase.’

Robot: Wow! I think there's still room for another flower! Let's *add one flower*.
(A helpful arrow appears on the screen.)
→ Child adds another flower.

- In case of correct response, robot says 'yay' and the tablet makes a happy sound, and the child and the robot receive a star
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'put another flower in the vase on the tablet'
- If nothing happens, the robot says 'put another flower in the vase on the tablet'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm putting another flower in the vase.'

Robot: Cool, now we have six flowers in the vase! Touch the vase to hear the English word for six.
→ Child touches vase.

- In case of correct response, tablet says '*six'* and the robot says '*six, say six*
    - If the child says *six* or something else, the robot says: 'good job, *six flowers*!'
    - If the child does not say anything, the robot says: 'say *six'*
        - If the child still doesn't say anything, the robot says 'it was *six,* let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the green vase on the tablet'
- If nothing happens, the robot says 'do you see the green vase? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the green vase.'

Robot: Great, there are six flowers in the vase! Now, let's fill the yellow vase. Touch the yellow vase and we'll hear what to do.
→ Child touches yellow vase.

- In case of correct response, tablet says '*add five flowers'*
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the yellow vase on the tablet'
- If nothing happens, the robot says 'do you see the yellow vase? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the yellow vase.'

Robot: Cool! Can you *add five flowers?*
(A helpful arrow appears on the screen.)
→ Child drags five flowers to the vase, one at a time. While dragging the tablet counts 'one*, two, three, four, five'*

- In case of correct response, robot says 'good job!' and the tablet makes a happy, and the child and the robot receive a star
- If the child touches the flower but does not drag it to the vase, robot says 'very good, that's the flower, now drag it to the vase'
- If the child drags one flower to the vase and then stops, the robot says 'very good, that was one flower, now also put four more flowers in the vase'

- If the child drags two flowers to the vase and then stops, the robot says 'very good, now also drag three more flowers to the vase'
- If the child drags three flowers to the vase and then stops, the robot says 'very good, now also drag two more flowers to the vase'
- If the child drags four flowers to the vase and then stops, the robot says 'very good, now also drag the last one to the vase'
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the flowers in the vase!

Robot: There's still room for another flower! Let's *add two flowers*.
(A helpful arrow appears on the screen.)
→ Child adds another two flowers, one at a time. After it has added the first flower, the tablet says '*six'*

- In case of correct response, robot says 'yay' and the tablet makes a happy sound, and the child and the robot receive a star
- If the child drags one flower to the vase and then stops, the robot says 'very good, that was one flower, now also put another flower in the vase'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'put two flowers in the vase on the tablet'
- If nothing happens, the robot says 'put two flowers in the vase on the tablet'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm putting two flowers in the vase.'

Robot: Cool, now we have seven flowers in the vase! Touch the vase to hear the English word for seven.
→ Child touches vase.

- In case of correct response, tablet says '*seven'* and the robot says '*seven, say seven'*
    - If the child says *seven* or something else, the robot says: 'good job, *seven flowers*!'
    - If the child does not say anything, the robot says: 'say *seven'*
        - If the child still doesn't say anything, the robot says 'it was *seven*, let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the yellow vase on the tablet'
- If nothing happens, the robot says 'do you see the yellow vase? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the yellow vase.'

Robot: Great! We've filled all the vases with flowers. The last one has a lot, it has *seven flowers*! Now, which vase has *more flowers* than the green vase? Touch the vase that has *more flowers* than the green vase.
→ Child touches yellow vase.

- In case of correct response, tablet says '*more'* and the robot says 'good job, *seven flowers is more than six flowers'*
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the vase that has more flowers than the green vase on the tablet'

- If nothing happens, the robot says 'do you see the vase that has more flowers than the green one? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the vase that has more flowers than the green one.'

Robot: Great! Now, there's also a vase that has fewer flowers than the green vase! Touch the tablet and we'll hear the English word for fewer.
→ Child touches orange vase.

- In case of correct response, tablet says '*fewer'* and the robot says '*fewer*, say *fewer'*
    - If the child says *'fewer'* or something else, the robot says: 'good job, *fewer flowers,* because *four flowers is fewer than six flowers*!'
    - If the child does not say anything, the robot says: 'say *fewer'*
        - If the child still doesn't say anything, the robot says 'it was *fewer,* let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the vase that has fewer flowers than the green vase on the tablet'
- If nothing happens, the robot says 'do you see the vase that has fewer flowers than the green one? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the vase that has fewer flowers than the green one.'

Robot: Hm I think the yellow vase is a bit too full now. Let's take away *one flower*. Take away one flower and put in the green vase, then we'll hear what the English word for take away is.
→ Child takes one flower from yellow vase and puts it in the green vase.

- In case of correct response, tablet says '*take away'* and the robot says '*take away,* say *take away'*
    - If the child says '*take away'* or something else, the robot says: 'good job, *take away*'
    - If the child does not say anything, the robot says: 'say *take away'*
        - If the child still doesn't say anything, the robot says 'it was *take away,* let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the orange vase on the tablet'
- If nothing happens, the robot says 'do you see the orange vase? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching the orange vase.'

Robot: The tablet said to *take away one flower* and now we have *fewer flowers* than before. It now only has *six flowers* left, and that is *fewer than seven*! Okay, let's put away our nice vases to make some room! We should put them on the shelves, but they're filled with buckets. Touch a bucket to hear the English word for bucket.
→ Child touches bucket.

- In case of correct response, tablet says '*bucket'* and the robot says '*bucket,* say *bucket'*
    - If the child says *bucket* or something else, the robot says: 'good job, *bucket'*
    - If the child does not say anything, the robot says: 'say *bucket'*

        - If the child still doesn't say anything, the robot says 'it was *bucket,* let's see what we have to do now'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'touch the bucket on the tablet'
- If nothing happens, the robot says 'do you see the buckets? Touch one on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm touching a bucket.'

Robot: Wow there are a lot of buckets, let's count them by touching them.
→ Child touches buckets. While touching them, the tablet says '*one, two, three, four, five, six, seven'*
Robot: Okay, there are *seven buckets* on the shelves! I guess we need to *take away* a lot of buckets to make space for the vases. *Take away a bucket* to make room for the orange vase.
(A helpful arrow appears on the screen.)
→ Child takes away a bucket.

- In case of correct response, robot says 'great, now we have *six buckets* left, we have *fewer buckets* than before, because *six is fewer than seven*'
- If the child takes away one bucket and then stops, the robot says 'very good, that was one bucket, now also take away another bucket'
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'take two buckets from the shelves'
- If nothing happens, the robot says 'take away two buckets from the shelves'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm taking away two buckets.'

Robot: Okay you did great when you had to *take away one bucket*, now let's put the vase on the shelve.
(A helpful arrow appears on the screen.)
→ Child puts vase on shelve.

- In case of correct response, robot says 'yay' and the tablet makes a happy sound, and the child and the robot receive a star
- If the child touches something else, the robot says 'no that wasn't it, try again'
- If the child says something, the robot says 'put the vase on the shelve'
- If nothing happens, the robot says 'put the vase on the shelve'
    - If still nothing happens, the robot shows the child how to do it: 'Look, I'm putting the vase on the shelve.'

Robot: Let's also *take away five buckets* to make room for the other two vases!
(A helpful arrow appears on the screen.)
→ Child takes away five buckets, one at a time.

- In case of correct response, robot says 'yay'
- If the child touches the bucket but does not take it away, robot says 'very good, that's the bucket, now take it from the shelve'
- If the child takes away one bucket and then stops, the robot says 'very good, that was one bucket, now also take away four more buckets'
- If the child takes away two buckets and then stops, the robot says 'very good, now also take away three more buckets'

- If the child takes away three buckets and then stops, the robot says ‘very good, now also take away two more buckets’
- If the child takes away four buckets and then stops, the robot says ‘very good, now also take away the last bucket’
- If the child doesn’t do anything/touches the tablet randomly, the robot says ‘let’s take the buckets from the shelves!

Robot: The tablet said to *take away* the buckets and now we have *fewer buckets* than before. There is only one left! Enough room on the shelves to put the vases there. Put the vases on the shelves.
(A helpful arrow appears on the screen.)
→ Child puts vases on the shelves.

- In case of correct response, robot says ‘yay’ and the tablet makes a happy sound, and the child and the robot receive a star
- If the child drags one vase to the shelve and then stops, the robot says ‘very good, that was one vase, now also put the other vase on the shelve’
- If the child touches something else, the robot says ‘no that wasn’t it, try again’
- If the child says something, the robot says ‘put the two vases on the shelve’
- If nothing happens, the robot says ‘put the two vases on the shelve’
    - If still nothing happens, the robot shows the child how to do it: ‘Look, I’m putting the two vases on the shelves.’

Robot: Wow look how good we helped in the flower shop! I think the owner will be very pleased with us! Let’s play another game!

2. Space Domain

LESSON 1 - SESSION 1

Setting: Fruit Shop
Activity: Organizing the fruit shop
Target words: on, in, between, above, below, and next to
Support words: put, cat, ball, box, apple, and fruit

How to read:
- Text in *italics* is speech in L2 (English)
- Text in regular font is English translation of what Robot actually say in L1
- Text in [square brackets] specifies action by Robot/Tablet
- Text in {braces} specifies input detection by Robot/Tablet

<u>Learning</u>
Tablet: [shows a map of the town; two locations, a blue store and a red store, are available]
Robot: Where should we go today? <Child’s name>, pick a place!
Child: {touches one of the available locations}
→ If child does not touch one of the locations for 2 seconds,
Robot: Okay, I am going to choose then! Can you touch the blue store for me?
→ If child does not touch the blue store for 2 seconds,

Robot: This place! [moves the hand towards the tablet and "touches" the blue store]

Tablet: [highlights the blue shop]

Robot: Let's go! [marches in place]

Tablet: [The robot and child avatars on screen move, synchronized with the robot's march. The avatars get to a fruit shop (regardless of which store the child chooses, they will end up in the fruit shop). There are a bunch of fruits as well as boxes in the fruit shop.]

Robot: It looks like a fruit shop. I see many apples and oranges.

Tablet: [A cat (or another small animal appeared in a previous session) walks into the scene]

Robot: Oh, kitty cat. I wonder what she is doing here. Anyway, let's start our game!

Tablet: [zooms into one of the boxes. The background diminishes and the screen shows the box and an apple only]

Robot: <Child's name>, can you touch somewhere on screen?

REPEAT THE FOLLOWING INDENTED SECTION 6 TIMES WITH DIFFERENT PREPOSITIONS (ON, IN, BETWEEN, ABOVE, BELOW, NEXT TO).

Child: {touches the screen}

→ If no touch was detected for 2 seconds,

- **Robot** says one of the following sentences:
  - Option 1: "Can you touch the screen?"
  - Option 2: "Okay, I am going to touch it [move down the right arm, pretending to touch the screen]"

Tablet: {the apple move to an appropriate location and tablet says a preposition and sentence that describe the spatial relation depicted there (e.g., "*In. The apple is IN the box*")}

Robot: Let's repeat the sentence together! *Three, two, one…* <sentence (e.g., "*The apple is IN the box...*")>. Every once in a while, translate the sentence into L2 (e.g., "Maybe '*in'* means 'in'" or "Maybe *'the apple is IN the box*' means 'the apple in the box'").

Tablet: {Then, cat goes to the same location as the apple. The tablet says the same sentence with the cat as the subject (e.g., "*In. The cat is IN the box*")

Robot: Can you touch the screen again?

Child: {touches the screen}

→ Wait for 2 seconds and move on regardless of whether the child touches the screen or not

Tablet: [zooms out and show the whole store]

Robot: Now we see the whole store. What's next? Touch the screen again!

Child: {touches the screen}

→ If no touch was detected for 2 seconds,

- **Robot**: Okay, I am going to touch it [moves down the right arm, pretending to touch the screen]

Tablet: Nothing happens.

Robot: Hmmm… Maybe it didn't detect the touch. Let's tap the screen again! Tap many times! [with tapping gesture]
Tablet: [all fruits fall off with loud sound]
Robot: Oops, we made a mess! We have to put them back!

REPEAT THE FOLLOWING INDENTED SECTION 6 TIMES WITH DIFFERENT PREPOSITIONS (ON, IN, BETWEEN, ABOVE, BELOW, NEXT TO).

Tablet: [highlights one of the fruits]
Robot: Alright, let's put this fruit <spatial relation> (one of the 6 relations; e.g., *in the box*).
Child: {drag and drop the fruit}
→ If the fruit is not at the correct location after 2 seconds,
Robot: *The fruit <spatial relation>*
→ If the bottle was not at the correct location for another 2 seconds,
Robot: [points to the fruit and the box] while saying "*The fruit <spatial relation>*"
→ If the fruit was not at the correct location for another 2 seconds,
Robot: I think the game wants us to put the fruit <spatial relation>"
→ If the fruit was not at the correct location for another 2 seconds,
Robot: Hmmm, let me try it! [points to the fruit with its right arm and swings the right arm" while saying "*put the fruit <spatial relation>*"
Tablet: [highlights the area where the fruit is located and says a preposition and sentence that describe the spatial relation depicted there (e.g., "*In. The fruit is in the box*")]
Robot: Alright, we got it. {Repeat the sentence (e.g., "*The fruit is in the box...*")}

Robot: Phew, now it is all good.
Tablet: [The cat moves around the fruit shop and mess up everything]
Robot: Nooooo! We just put them back! I guess we have to do it again… This time, let's put the cat in one of the boxes first so that it won't make a mess. {"points" to one of the boxes} *Put the cat in the box!*
Child: {drag and drop the cat into the box}
→ If the cat is not placed in the box.
Robot says "Okay, I will do it" and {moves down the right arm, pretending to drag and drop the cat.}

<u>Practice</u>

REPEAT THE FOLLOWING INDENTED SECTION 6 TIMES WITH DIFFERENT PREPOSITIONS (ON, IN, BETWEEN, ABOVE, BELOW, NEXT TO).

Tablet: [highlights one of the fruits]
Robot: Alright, let's put this fruit <spatial relation> (one of the 6 relations; e.g., *in the box*).

Child: {drag and drop the fruit}
→ If the fruit is not at the correct location after 2 seconds,
Robot: *The fruit <spatial relation>*
→ If the bottle was not at the correct location for another 2 seconds,
Robot: [points to the fruit and the box] while saying "*The fruit <spatial relation>*"
→ If the fruit was not at the correct location for another 2 seconds,
Robot: I think the game wants us to put the fruit <spatial relation>"
→ If the fruit was not at the correct location for another 2 seconds,
Robot: Hmmm, let me try it! [points to the fruit with its right arm and swings the right arm" while saying "*put the fruit <spatial relation>*"
Tablet: [highlights the area where the fruit is located and says a preposition and sentence that describe the spatial relation depicted there (e.g., "*In. The fruit is in the box*")]

Task
Robot: Hmmm, what's next?
Tablet: [An apple pops up on the screen]
Robot: Look, there is an apple. Do you want to touch it?
Child: {touches the apple?}
→ If the apple was not touched for 2 seconds,
- Robot says "Touch the apple!" once

→ If the apple was not touched for another 2 seconds,
- Robot says "Then I am touching the apple!" and [extends the right arm to the direction of the tablet]

Tablet: *This is an apple.*
Robot: *This is an apple.*

REPEAT THE FOLLOWING INDENTED SECTION 6 TIMES WITH DIFFERENT PREPOSITIONS (ON, IN, BETWEEN, ABOVE, BELOW, NEXT TO) AND DIFFERENT REFERENCE OBJECTS (BASKET, PLATE, CHAIR, BOX)
Tablet: *Put the apple on the plate.* {highlights the plate}
Robot: *Put the apple on the plate…?* Can you do that?
Child: {drags and drops the apple on the plate?}
→ If the apple was not located at the correct location (i.e., on plate) after 2 seconds,
- Tablet makes a buzz sound
- Robot says "Oh no! *Put the apple on the plate*…" once

→ If the apple was not at the correct location for another 2 seconds,
- Robot [points to the apple and the plate] while saying "*Put the apple on the plate*"

→ If the apple was not at the correct location for another 2 seconds,

- Robot says "I think the game wants us to put the apple on the plate"

→ If the apple was not at the correct location for another 2 seconds,

- Robot says "Hmmm, let me try it!" and [points to the apple with its right arm and swings the right arm to the direction of the plate" while saying "*Put the apple on the plate*"

Tablet: [makes some happy sound and confetti and flowers appear] "*The apple is on the plate*."

Robot: Yay, we got it right/Super/Awesome/Great/Well done/Bravo/Excellent!

End of lesson
Tablet: Great job! You are all done!
Robot: I think we finished the game! That was fun! Shall we play together soon again?
Robot: [waits for Child to respond] Let's play again! Bye bye!

LESSON 1 - SESSION 2

Setting: Restaurant
Activity: Serving customers
Target words: across, left, right, behind, and front
Support words: plate, fork, glass, knife, bottle
Duration: 15 minutes

How to read:
- Text in *italics* and highlighted in yellow is speech in L2 (English)
- Text in regular font is English translation of what Robot actually say in L1 (Turkish)
- Text in [square brackets] specifies action by Robot/Tablet
- Text in {braces} specifies input detection by Robot/Tablet

Part 1. Recap and Learning
Robot: Hi, <Child's name>! Today we are going to a restaurant! Let's go!
[marches in place]
Tablet: [The robot and child avatars on screen move, synchronized with the robot's walk. The avatars get to a restaurant. The restaurant appears across the street.]
Robot: Yay, we got to the restaurant! Hmm, we have to cross the road, because the restaurant is across the street.
Tablet: *Restaurant is across the street.*
Robot: "*Restaurant"* might mean restaurant in "restaurant." *Restaurant!* I like this word! Let's say it, <Child's name>!
Child: (talks)
Robot: Let's touch the restaurant.
Child: {touches the screen}

→ If no touch was detected for 2 seconds,
Robot says "Let's touch the restaurant. Can you touch the screen?"
Tablet: *Restaurant.*
Robot: Oh, I like this! Let's touch it again!
Child: {touches the screen}
→ If no touch was detected for 2 seconds,
Robot says "Let's touch the restaurant. Can you touch the screen? "
Tablet: *Restaurant is across the street.*
Robot: Well, the tablet said something… What was it? Can you please touch it again?
Child: {touches the screen}
→ If no touch was detected for 2 seconds,
Robot says "Let's touch restaurant. Can you touch the screen? "
Tablet: *Restaurant is across the street.*
Robot: Oh, *across the street*! Hmm does it mean "across the street" in Turkish? Might be so! Let's try to repeat it together! *Across.*
Child: (talks)
Robot: *Across*. Across. I guess it said *Restaurant is across the street.* Do you think that I can say it properly? Could you repeat it for me?
Child: (talks)
Robot: *Restaurant is across the street.* Let's say again!
Child: (talks)
Robot: I should say it once more. *Restaurant is across the street.* Restaurant is across the street. Could you repeat it again?
Child: (talks)
Robot: OK, I guess I can remember this. Oh, look!
Tablet: [A cat walks into the scene and stops in front of the restaurant.]
Robot: Not that cat again! Remember, we call cat "*cat*" in English. Let's repeat it! *Cat.*
Child: (talks)
Tablet: *Cat. Cat is in front of the restaurant*.
Robot: Oh I guess it means that cat is in front of the restaurant. *In front of* might mean in front of. Let's say it!
Child: (talks)
Robot: *Cat is in front of the restaurant.* Touch the cat!
Child: {touches the screen}
→ If no touch was detected for 2 seconds,
Robot says "Let's touch cat. Can you touch the screen?"
Tablet: {highlights the area touched by the child and says *Cat is in front of the restaurant*}
Tablet: [A ball appears in the scene. Cat plays with the ball.]
Robot: Look, the cat has a ball.
Tablet: *Ball. Ball is in front of the restaurant*
Robot: Ball is in front of the restaurant. *Ball is in front of the restaurant.* Try to touch the ball!
Child: {touches the screen}
→ If no touch was detected for 2 seconds,
Robot says "Let's touch ball. Can you touch the screen?"

Tablet: {highlights the area touched by the child and says *Ball is in front of the restaurant*}
Robot: Now, touch the cat again! *Cat.*
Child: {touches the screen}
→ If no touch was detected for 2 seconds,
Robot says "Let's touch cat. Can you touch the screen? "
Tablet: {highlights the area touched by the child and says *Cat is in front of the restaurant*}
Robot: Now, touch the ball again! *Ball.*
Child: {touches the screen}
→ If no touch was detected for 2 seconds,
Robot says "Let's touch ball. Can you touch the screen?"
Tablet: {highlights the area touched by the child and says *Ball is in front of the restaurant*}
Robot: Yay! I am having so much fun. Hey, let's enter the restaurant.
Tablet: {the scene changes}
Robot: Look! There is a table inside.
Tablet: {shows the stuff next to each other at the top of the table (from top view)}

REPEAT THE FOLLOWING INDENTED SECTION 3 TIMES WITH DIFFERENT REFERENCE OBJECTS (PLATE, FORK, GLASS, KNIFE, BOTTLE) (objects are always on the table)

Tablet: [A knife gets highlighted on the tablet screen]
Robot: Look, there is a knife. We use it for cutting food, don't we? Let's try to touch it!
Child: {touches the knife?}
→ If the knife was not touched for 2 seconds, Robot says "Touch the knife!" once
→ If the knife was not touched for another 2 seconds, Robot says "Then I am touching the knife!" and [extend the right arm to the direction the tablet].
Tablet: *This is a knife. The knife is on the table.*
Robot: Ohhh, I think fork is called "*knife*" in English. *Knife!* Now your turn. Repeat it!
Child: {says "*knife*"?}
→ If no speech is detected for 2 seconds, Robot says "Say *knife*!" once.
Robot: The knife is on the table. Let's say this in English: *The knife is on the table*. Say it.
Child: {says "*The knife is on the table*"?}
→ If no speech is detected for 2 seconds, Robot says "Say *the knife is on the table*!"

Robot: You know what? They need our help because customers will arrive soon but the tables are not ready. I guess we can help them! Now let's watch the video first and learn where we should place the items.
Tablet: (Plays an animation: The screen shows the table, the glass, and the plate. Other objects diminish. The glass moves around the plate to show the target relations -- LEFT, RIGHT, BEHIND, FRONT).
Tablet: {for each move it describes the relation in L1 (e.g., the glass is on the left of the plate or the glass is behind the plate)

REPEAT THE FOLLOWING INDENTED SECTION 4 TIMES USING THESE SENTENCES:
1. The fork is on the left of the plate
2. The bottle is behind the plate
3. The knife is on the right of the plate
4. The glass is in front of the bottle

Tablet: (The screen shows the table, the glass, and the plate. Other objects disappears. The first object moves around the second object to show the target relations -- LEFT, RIGHT, BEHIND, FRONT).
Robot: Let's touch the X [first object]!
Child: {touches the screen}
→ If no touch was detected for 2 seconds,
Robot says one of the following sentences:
- Option 1: "Let's touch X. Can you touch the screen? "
- Option 2: "Okay, I am going to touch it (move down the right arm down, pretending to touch the screen)"

Tablet: {for each move it describes the relation in L2 (e.g., *the fork is on the left of the plate or the bottle is behind the plate*}
Robot: {Repeat the sentence (e.g., "*the fork is on the left of the plate*") and, every once in a while, translate the sentence into L1}
Tablet: *Place the fork*
Robot: Wait, what? *Place*. What is it? Hmm… might be place in Turkish? Do you agree X?
Child: (talks)
Robot: hmm yes! *Place*. Place. I should repeat it to remember for the next time. Can you repeat it for me?
Child: (talks)
Robot: *Place*. Place.
Tablet: *Place the fork.*
Robot: Hey, wait a second! Once more *Place*. Place. Say it X!
Child: (talks)
Robot: OK, now we are ready to help! Let's set the table before customers arrive! It is going tell us what to do.

Part 2. Testing
REPEAT THE FOLLOWING INDENTED SECTION 4 TIMES USING THESE SENTENCES:
1. Place the plate in front of the bottle
2. Place the fork behind the plate
3. Place the glass to the right of the bottle
4. Place the knife to the left of the fork

Tablet: [Say sentence #1]
Robot: Let's do it X!

Child: {drags and drops the plate in front of the bottle?}
→ If the plate was not located at the correct location after 2 seconds,
- Tablet makes a buzz sound
- Robot says "Oh no! *Place the plate in front of the bottle*…" once
→ If the plate was not at the correct location for another 2 seconds, Robot [points to the plate and the bottle] while saying "*Place the plate in front of the bottle*"
→ If the plate was not at the correct location for another 2 seconds, Robot says "I think the game wants us to place the plate in front of the bottle"
→ If the plate was not at the correct location for another 2 seconds, Robot says "Hmmm, let me try it!" and [points to the plate with its right arm and swings the right arm to the direction of the bottle" while saying "*Place the plate in front of the bottle*"

3. Mental States Domain
LESSON 1 - SESSION 1

Participants: Child, Robot
Lesson program: Emotion words, the pronoun "I am" and the mental state verb "feel"
Lesson theme: Hospital
Activity: Treating patients

Text said in English is indicated in italics, the rest of text is said in the L1.

Target words: Happy, sad, angry, I am, feel
Support words: doctor, boy, girl

Introduction (warming up): about 2-5 minutes (child should already be familiar with this procedure from earlier lessons, so this is just a reminder).
Robot: Hello… (name of child). Remember me? I am Robyn. How are you doing…(name of child)?
Child: (probably ok, or something else, answer does not matter).
Robot: Remember we visited the town? Let's see where we are going to visit today! Touch the tablet to begin.
(Child touches tablet. The screen displays the town and the robot and child avatars are walking towards the hospital.)
(if the child does not touch the tablet the robot says, Oh let me do it! And "touches" the tablet to start the display).
Child: (probably yes, answer does not matter)
Robot: Today we are going to help at the hospital. Look!
(Robot "touches" tablet where the hospital is and the hospital scenery is displayed).

(Robot takes a moment to look at the scenery. This allows the child time to do the same).

Robot: Look (points) there is a doctor. Let's touch the doctor.
→ Child touches the doctor.

- In case of correct response, tablet says '*doctor'*
- If the child touches something else, the robot says 'no that wasn't the doctor, try again'
- If the child says something, the robot says 'touch it on the tablet' or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says 'do you see the doctor? Touch her on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'this was the doctor! Look, she's over there' (points to the doctor and "touches" her) – the tablet then says: '*doctor'*

Robot: Did you hear that? The tablet said *doctor*, I think that's the English word for doctor. Say *doctor*.
Child: *doctor.*

- If the child says '*doctor'* or something else (we probably can't recognize whether the child says something correctly), the robot says: 'good job!' (maybe the experimenter should give feedback here to make sure the child repeats the word as correctly as possible, and to encourage the child to repeat the words)
- If the child does not say anything, the robot says: 'let's do it together! One, two, three: *doctor*
    - If the child still doesn't say anything, the experimenter may help or the robot can say: 'I'm sure you can do it, say after me: *doctor*

Robot: Cool, we're learning English words again!

Robot: I see a girl over there. Let's touch the girl. Now it is my turn!
→ Robot "touches" the girl.

- Tablet says '*girl'*

Robot: Hey! The tablet said *girl*, then that's the English word for girl. Say *girl*.
Child: *girl.*

- If the child says 'girl' or something else (we probably can't recognize whether the child says something correctly), the robot says: 'good job!' (maybe the experimenter should give feedback here to make sure the child repeats the word as correct as possible, and to encourage the child to repeat the words)
- If the child does not say anything, the robot says: 'let's do it together! One, two, three: *girl*
    - If the child still doesn't say anything, the experimenter may help or the robot can say: 'I'm sure you can do it, say after me: *girl*

{note – if in the first go the child did not do the task, then the child gets a turn here}

Robot: That is fun! Let's do one more. It is your turn again. Can you touch the boy?
Robot: Look (points) there is boy. Let's touch the doctor.
→ Child touches the boy.

- In case of correct response, tablet says '*boy'*

- If the child touches something else, the robot says ‘no that wasn’t the boy, try again’
- If the child says something, the robot says ‘touch him on the tablet’ or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says ‘do you see the boy? Touch him on the tablet!’
    - If still nothing happens, the robot shows the child how to do it: ‘this was the *boy*! Look, it’s over there’ (points to the *boy* and “touches” him) – the tablet then says: ‘*boy’*

Robot: The tablet said *boy*, that must be the English word for boy. Say *boy*.
Child: *boy.*

- If the child says ‘*boy’* or something else (we probably can’t recognize whether the child says something correctly), the robot says: ‘good job!’ (maybe the experimenter should give feedback here to make sure the child repeats the word as correct as possible, and to encourage the child to repeat the words)
- If the child does not say anything, the robot says: ‘let’s do it together! One, two, three: *boy*
    - If the child still doesn’t say anything, the experimenter may help or the robot can say: ‘I’m sure you can do it, say after me: *boy*

{note – if in the last go the child did the task, then the robot gets a turn here}

<u>Modelling of words about 10-15 minutes.</u>
Robot: Look, there is a *girl*. She is sad. Can you touch her?
(the *girl* is crying and her knee and arm are hurt)

[this is schematic view – the tablet scene would be more realistic and display several figures that are likely to be in a hospital]
→ Child touches the sad girl.

- In case of correct response the tablet says ‘*sad’*
- If the child touches something else, the robot says ‘no that wasn’t it, try again’
- If the child says something, the robot says ‘touch it on the tablet’
- If nothing happens, the robot says ‘do you see the sad *girl*? Touch her on the tablet!’
    - If still nothing happens, the robot shows the child how to do it: ‘this was the sad *girl*! Look, I’m touching the sad *girl*.’ Tablet says ‘*sad’*

Robot: Ah, sad is in English *sad.* Say *sad.*
Child: *sad.*

- If the child says *sad* or something else, the robot says 'good job!'
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *sad*
    - If the child still doesn't say anything, the robot can say 'let's say it together! One, two, three… *sad*

Robot: Now let's help the *sad girl*. She hurt her knee and her arm. Can you give her a plaster?
(an arrow appears that points to a plaster in the scenery).
→ Child drags the plaster to the girl's knee or arm.

- In case of correct response, robot says 'good job! The *girl* is no longer *sad.* She is happy! The girl smiles and the robot and the child are awarded a small star.
- If the child touches the plaster but does not drag it to the girl, the robot says 'very good, that's the plaster, now drag it to the *girl*.
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's put the plaster on her knee!'
    - Still nothing: the robot says 'let me show you how to do it' and "drags" the plaster to the girl and says ´I am putting the plaster on her knee, now the *girl* is not *sad* she is happy.

Robot: Now it is my turn. I am going to put the plaster on her arm (or knee, if the child places the first plaster on the arm).
(the robot "drags" the plaster to the girl's arm)
Robot: I put the plaster on her arm. Now she is no longer *sad.*

{note – if in the first go the child did not do the task, then the child gets a turn here}

Robot: When I am *sad* I do this.
(robot looks down and makes a puts arms in lap – to indicate sad).


(possible postures)
Robot: What do you do when you are *sad*?
Child: (makes a sad movement or sound)

- If the child does something the robot says – yes I can see you are *sad.*
- If the child does not respond, the robot says - *Sad* is sad in English. can you show me what you do when you are *sad?*
- If the child still does not respond the robot says let's do it together one, two three…. (robot makes a sad gesture – looking down with arms in lap).

Robot: Great! Let's look what the *doctor* is doing! He is talking to the *boy*. Look the *boy* is crying. He is *sad* too. Let's go into the doctor's office and listen. Can you open the door?
→ Child touches the door.

- In case of correct response, the boy says '*I am sad'*
- If the child touches something else, the robot says 'no that wasn't the door, try again'
- If the child says something, the robot says 'touch it on the tablet' or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says 'do you see the door? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'this was the door! Look, it's over there' (points to the door and "touches" it) – the *boy* then says: '*I am sad'*

Robot: Hey I know! *I am sad* is I am sad in English. *I am* is I am in English.
Robot: (points to itself): *I am*
Robot: Say it too, point to yourself and say *I am.*
Child: (points to itself) *I am.*

- If the child says *I* am or something else, the robot says 'good job!'
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *I am* (robot points to itself)
    - If the child still doesn't say anything, the robot can say 'let's say it together! One, two, three… *I am* (robot points to itself)

Robot: I can say I am Robyn in English. *I am Robyn.* And who are you? Can you say *I am* (name of child)?
Child: *I am* (own name).

- If the child says the correct utterance or something else (we probably can't recognize whether the child says something correctly), the robot says: 'good job!' (maybe the experimenter should give feedback here to make sure the child repeats the word as correct as possible, and to encourage the child to repeat the words)
- If the child does not say anything, the robot says: 'let's do it together! One, two, three: *I am* (name of child)
    - If the child still doesn't say anything, the experimenter may help or the robot can say: 'I'm sure you can do it, say after me: *I am* (name of child)

Robot: when you are *sad* you can say *I am sad* but you can also say *I* feel *sad,* I feel sad. I wonder how do say that in English. Maybe if we touch the *boy* again he will say that? Can you touch the *boy*?
→ Child touches the boy.

- In case of correct response, the boy says '*I feel sad'* [the word 'feel' should be stressed here]
- If the child touches something else, the robot says 'no that wasn't the *boy*, try again'
- If the child says something, the robot says 'touch it on the tablet' or the experimenter encourages the child to touch the tablet

- If nothing happens, the robot says ‘do you see the *boy*? Touch him on the tablet!’
    - If still nothing happens, the robot shows the child how to do it: ‘this was the *boy*! Look, it’s over there’ (points to the boy and “touches” it) – the boy then says: ‘*I feel sad’* [the word ‘feel’ should be stressed here].

Robot: Hey that is nice! *Feel* is the English word for feel. So when you are sad you can say *I am sad* or *I feel sad.* Say *feel*
Child: *feel*

- If the child says *feel* or something else, the robot says ‘good job!’
- If the child does not say anything, the robot says ‘I know you can do it, say it just like I do: *feel*
    - If the child still doesn’t say anything, the robot can say ‘let’s say it together! One, two, three… *feel*

Robot: Let’s help the *boy.* Let’s give him the medicine to make him better. Can you drag the medicine to the *boy?*
[an arrow appears pointing to a medicine bottle]
→ Child drags the medicine to the boy.

- In case of correct response, robot says ‘good job! The *boy* is much better. The *boy* stops crying and the robot and the child are awarded a small star.
- If the child touches the medicine but does not drag it to the boy, the robot says ‘very good, that’s the medicine, now drag it to the *boy*.
- If the child doesn’t do anything/touches the tablet randomly, the robot says ‘let’s give the medicine to the *boy’*
    - Still nothing: the robot says ‘let me show you how to do it’ and “drags” the medicine to the boy and says ´I am giving the medicine to the *boy*. Look he is much better now’.

Robot: When *I feel sad* I do this.
(robot looks down and makes a puts arms in lap – to indicate sad).

(possible postures)

Robot: What do you do when you *feel sad*?
Child: (makes a sad movement or sound)

- If the child does something the robot says – yes I can see you *feel sad.*
- If the child does not respond, the robot says - *Sad* is sad in English. can you show me what you do when you *feel sad?*
- If the child still does not respond the robot says let’s do it together one, two three…. (robot makes a sad gesture – looking down with arms in lap).

Robot: Let's look if we can help more people. Look at that man in bed. He wants to drink, but his cup is empty. Someone drank all his water! He is angry! Can you touch the *man*?
→ Child touches the man.

- In case of correct response, man says '*I am angry!'*
- If the child touches something else, the robot says 'no that wasn't the man, try again'
- If the child says something, the robot says 'touch it on the tablet' or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says 'do you see the man? Touch it on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'this was the man! Look, he is over there' (points to the *man* and "touches" it) – the man then says: '*I am angry'*

Robot: Hey, did you hear that? *Angry* is angry in English. I am angry is *I am angry.* Say *angry*
Child: *angry.*

- If the child says *angry* or something else, the robot says 'good job!'
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *angry*
    - If the child still doesn't say anything, the robot can say 'let's say it together! One, two, three… *angry*

Robot: Let me have a go as well! I am going to touch the man again!
Robot "touches" the man and the man looks angry and says *'I feel angry'*
Robot: I remember *I feel angry* is I feel angry and *I am angry* is I am angry. Can you say *I feel angry?*
Child: *I feel angry.*

- If the child says *I feel angry* or something else, the robot says 'good job!'
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *I feel angry*
    - If the child still doesn't say anything, the robot can say 'let's say it together! One, two, three… *I feel angry*

Robot: Can you fill the cup with water? The jug is there (an arrow appears that points to a jug of water).
→ Child drags the jug to the cup.

- In case of correct response, robot says 'good job! The man is no longer *angry.* He can drink! The man drinks and the robot and the child are awarded a small star.
- If the child touches the jug but does not drag it to the cup, the robot says 'very good, that's the jug, now drag it to the cup.
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's bring the jug to the cup to pour the water!'
    - Still nothing: the robot says 'let me show you how to do it' and "drags" the jug to the cup and says ´I am pouring water into the cup. Now the man is not *angry.* He can drink.

Robot: Now it is my turn. I am going to give him more water.

(robot "drags" the jug to the cup and pours water, the *man* drinks).
Robot: The man is no longer *angry*. He has plenty of water to drink.

Robot: When *I feel angry* I do this (hands on the middle, head slightly bent forward and eyes flash red).

Example of a posture
Robot: then *I am angry* (points to itself)

Robot: What do you do when you *feel angry*?
Child: (makes an angry movement or sound)

- If the child does something the robot says – yes I can see you are *angry*.
- If the child does not respond, the robot says - *Angry* is angry in English. Can you show me what you do when you are *angry?*
- If the child still does not respond the robot says let's do it together one, two three…. (robot makes an angry gesture – l hands on the middle, head slightly bent forward and eyes flash red).

Robot: Great job! We got another star! Look at this *girl*, she looks very happy! Can you touch her?
(a smiling girl is seen hugging a teddy bear).
→ Child touches the girl.

- In case of correct response, girl says '*I am happy'*
- If the child touches something else, the robot says 'no that wasn't the happy *girl*, try again'
- If the child says something, the robot says 'touch it on the tablet' or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says 'do you see the happy *girl*? Touch her on the tablet!'
    - If still nothing happens, the robot shows the child how to do it: 'this was the happy *girl*! Look, she's over there' (points to the happy girl and "touches" her) – the girl then says: '*I am happy'.*

Robot: I know, *happy* is happy in English. Say *happy.*
Child: *happy.*

- If the child says *happy* or something else, the robot says 'good job!'
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *happy*
    - If the child still doesn't say anything, the robot can say 'let's say it together! One, two, three… *happy*

Robot: that was fun! Let's touch the *girl* again! Now it is my turn.
(robot "touches" the girl and the girl says "*I feel happy")*
Robot: Hey, now she said *I feel happy.* Remember what that means?
Child: yes / I feel happy (does not really matter, it is a chance to respond, but if the child does not respond or does not respond correctly, it does not matter, the robot provides the answer anyway).

Robot: yes, *I feel happy* means I feel happy. I think she likes her teddy bear.
Robot: Look! this *boy* wants a teddy bear as well. Can you give him the teddy bear to make him *happy?*
(an arrow appears that points to a teddy bear and arrow pointing to a boy).
→ Child drags the teddy bear to the boy.

- In case of correct response, the boy smiles and says '*I am happy'. The* robot says 'good job! The *boy* is *happy!* and the robot and the child are awarded a small star.
- If the child touches the teddy bear but does not drag it to the boy, the robot says 'very good, that's the teddy bear, now drag it to the *boy*.
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's bring the teddy bear to the *boy*!'
- Still nothing: the robot says 'let me show you how to do it' and "drags" the teddy bear to the boy. and says ´I am giving the teddy bear to the *boy*. Now he is *happy!* The boy smiles and says '*I am happy'. T*he robot and the child are awarded a small star.

Robot: Now it is my turn! I am going to give a teddy bear to this *boy* (an arrow appears pointing to another boy and another teddy bear).
(robot tries to get the teddy bear but fails).
Robot: oh no, I cannot do it. Can you please help give the teddy bear to the other *boy*?
→ Child drags the teddy bear to the boy.

- In case of correct response, the boy smiles and says *'I feel happy'. The* robot says 'Great job! Thank you!' The robot and the child are awarded a small star.
- If the child touches the teddy bear but does not drag it to the boy, the robot says 'very good, that's the teddy bear, now drag it to the *boy*.
- If the child doesn't do anything/touches the tablet randomly, the robot says 'let's bring the teddy bear to the *boy*!'
    - Still nothing: the robot says 'let me try again and "drags" the teddy bear to the boy and says ´I am giving the teddy bear to the *boy*.' The boy smiles and says *'I feel happy'.* The robot and the child are awarded a small star.

Robot: When *I feel happy, I* do like that
(robot puts arms in the air and says whoo! Or some other happy noise, eyes flash with colours).
Robot: then *I am happy.*

Example of a posture

Robot: (name of child) what do you do when you *feel happy?*
Child: (shows a happy movement or sound)

- If the child does something the robot says – yes I can see you are *happy.*
- If the child does not respond, the robot says - *Happy* is happy in English. can you show me what you do when you are *happy?*
- If the child still does not respond the robot says let's do it together one, two three…. (robot makes a happy sound and lifts arms in the air).

Task 1: ± 2-5 minutes

Robot: Let's say goodbye to all the people we met!
(in the scenery the figures appear in their original state, so sad, angry and happy)

Robot: Can you find the *girl* who said *I feel sad*?
→ Child touches the sad girl.

- In case of correct response, the girl says *I feel sad* and then points to her arm and says thanks for your help! And waves. The child and robot are awarded a small star.
- If the child touches something else, the robot says 'no that wasn't the *girl* that said *I feel sad*, try again'
- If the child says something, the robot says 'touch it on the tablet' or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says 'do you see the *sad girl*? Touch her on the tablet!'
- If still nothing happens, the robot says: 'let me try!' and 'touches' the sad girl. the girl says *I feel sad* and then points to her arm and says thanks for your help! And waves. The child and robot are awarded a small star.

Robot: Great! Let's go to the next one. Look that is the man he said *I am angry.* Can you find him?
→ Child touches the angry man.

- In case of correct response, the man says *I am angry* and then points to his cup of water and says thanks for your help! The man then waves and child and robot are awarded a small star.
- If the child touches something else, the robot says 'no that wasn't the man that said *I am angry*, try again'

- If the child says something, the robot says ‘touch it on the tablet’ or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says ‘do you see the *angry* man? Touch him on the tablet!’
- If still nothing happens, the robot says: ‘let me try!’ and ‘touches’ the angry man. The man says *I am angry* and then points to his cup of water and says thanks for your help! The man then waves and child and robot are awarded a star.

Robot: This is fun! Let’s find the *boy* that said *I am happy.* Can you find him?
→ Child touches the happy boy.

- In case of correct response, the boy says *I am happy* and then points to his teddy bear and says thanks for your help! The boy then waves and child and robot are awarded a small star.
- If the child touches something else, the robot says ‘no that wasn’t the *boy* that said *I am happy* try again’
- If the child says something, the robot says ‘touch it on the tablet’ or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says ‘do you see the *happy boy*? Touch him on the tablet!’
- If still nothing happens, the robot says: ‘let me try!’ and ‘touches’ the happy boy. The boy says *I am happy* and then points to his teddy bear and says thanks for your help! The boy then waves and child and robot are awarded a small star.

Robot: We are doing so well. This is fun! Let’s go to the last one, that is the *boy* that said *I feel happy.* Can you find him?
→ Child touches the happy boy.

- In case of correct response, the boy says *I feel happy* and then points to his teddy bear and says thanks for your help! The boy then waves and child and robot are awarded a small star.
- If the child touches something else, the robot says ‘no that wasn’t the *boy* that said *I feel happy*, try again’
- If the child says something, the robot says ‘touch it on the tablet’ or the experimenter encourages the child to touch the tablet
- If nothing happens, the robot says ‘do you see the *happy boy*? Touch him on the tablet!’
- If still nothing happens, the robot says: ‘let me try!’ and ‘touches’ the happy boy. The boy says *I feel happy* and then points to his teddy bear and says thanks for your help! The boy then waves and child and robot are awarded a small star.
-

{note – here the child could touch either one of the two happy boys first, the first boy says then *I am happy* the second boy says *I feel happy*}

<u>Task 2: about 2-5 minutes</u>
Robot: Let’s play that we are a doctor and a sick child. I will be the doctor and you fell and hurt your hand. You *feel sad*. Say *I feel sad.* [robot makes a sad gesture]

Child: *I feel sad.*

- If the child says *I feel sad* or something else, the robot says 'oh no, give me your hand, I will put a plaster on it' the robot then reaches out to the child and when the child gives the robot a hand, the robot "puts a plaster" on it with his other hand.
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *I feel sad*
    - If the child still doesn't say anything, the robot can say 'let's say it together! One, two, three… *I feel sad*

  The robot then says 'oh no, give me your hand, I will put a plaster on it' the robot then reaches out to the child and when the child gives the robot a hand, the robot "puts a plaster" on it with his other hand.

Robot: That was fun! Let's do another one. Now someone took your teddy bear and you are very *angry.* Say *I am angry!* [robot makes an angry gesture]
Child: *I am angry.*

- If the child says *I am angry* or something else, the robot says 'oh no! Wait, I will give you another teddy bear, there you go [robot pretends to give a teddy bear to the child]
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *I am angry*
    - If the child still doesn't say anything, the robot can say 'let's say it together! One, two, three… *I am angry*

  The robot then says 'oh no! Wait, I will give you another teddy bear, there you go [robot pretends to give a teddy bear to the child]

Robot: Now you *feel happy* with your teddy bear. Say *I feel happy!*[robot makes a happy gesture]
Child: *I feel happy.*

- If the child says *I feel happy* or something else, the robot says great! *I feel happy* too! [robot cheers and eyes flash in colours]
- If the child does not say anything, the robot says 'I know you can do it, say it just like I do: *I feel happy*
    - If the child still doesn't say anything, the robot can say 'let's say it together! One, two, three… *I feel happy*

The robot then says great! *I feel happy* too! [robot cheers and eyes flash in colours]

Ending of lesson:
(On the tablet, the 'home screen' with the town and the avatars pops back up again. The small stars all add up in in one big container and then a big star comes out with festive animation comes out.
Robot: Yay we had enough small stars to get a big one again! That was great fun again! *I am* very *happy!* Give me high five!
(child and robot give high five).

LESSON 2 - SESSION 3

Setting: Supermarket
Activity: Shopping
Target words: want, need, like, and love
Support words: (milk, juice, apple, orange), and carrot
Speech in L2 is indicated in *italics* and highlighted in yellow

Part 1: Teaching words (5-7 minutes)

Tablet: [shows the map of the town as usual]
Robot: <Child's name>, do you know where we are going today?
Child: {says something}
Robot: [waits for 5 seconds] Well, today we are going to a supermarket and do shopping! Let's go! [starts marching in place]
Tablet: [The child and robot avatars on screen go to the supermarket]
Robot: Alright, we are at the supermarket! Hmm, what should we buy first? I am thirsty now. Or, *I am thirsty.* See how I used the English sentence we learned? *I am thirsty.*
Tablet: *You are thirsty.*
[shows the drink section of the supermarket]
Robot: Wow, I am surprised! He knows? Or I should say *I am surprised, he knows.*
Tablet: *Milk?* [shows an image of a bottle of milk on the left] *Juice?* [shows an image of a bottle of juice on the right]
Robot: Hmmm… milk or juice… *milk... juice…*
Tablet: *Do you like milk?* [briefly draws a heart around the milk image] *Or you like juice?* [briefly draw a heart around the juice image].
Robot: I like *milk* better than *juice.*
Tablet: *You like milk?*
[draws a heart around the milk]
Robot: *You like milk…* I guess that is how to say "you like milk" in English. So the word is "*like*"... Then, *I like milk!* <Child's name>, can you touch the left one, or *left*. Please touch the *milk* and let him know that *I like milk.*
Child: {touches the milk}
Tablet: *You like milk.*
But, I do not give you milk.
[the images disappear]
Robot: Why did they disappear? Maybe we have to say that *we like milk*. <Child's name>, let's say "*we like milk*" together! *Three, two, one… We like milk!*
Robot: Hmmm maybe it is not enough to say that we like *milk*, "*we like milk.*" What do I say when I WANT something…
Tablet: *You want milk? Or you want juice?*
[the images reappear]
Robot: *You want milk…?* Ohhh, "*want*" must mean "want" in English! *Yes, I am thirsty and I like milk.* So I want milk. *I want milk! I do not want juice.* <Child's name>, can you say "*we want milk*" and touch the *milk*?
Child: (says "we want milk" and touches the image of milk)
Tablet: You want milk. [the milk image gets bigger while the juice image disappears]

Robot: We did it! <Child's name>, let's pretend we are drinking the *milk*!
[does drinking motion]
Tablet: [the amount of milk decreases, synchronized with the robot's drinking motion]
Robot: Wow, this is like magic! *I like milk. I am happy. I am not thirsty.* But now, *I am hungry. I want...* food!
Tablet: *You are hungry, and you want food.*
[shows the fruit and vegetable section of the supermarket]
Robot: Yes, *I am hungry and I want food.*
Tablet: *You want one apple?* [shows an image of an apple on the left] *Or you want one orange?* [shows an image of an orange on the right]
Robot: Wow. <Child's name>, which one do you like? *Apple* or *orange*? Let's choose the one you want.
Child: [touches one of the two images -- let's say apple for the sake of this script]
Tablet: *You want one apple.* [the apple image gets bigger while the orange image disappears]
Robot: *Yes, we want one apple.* Great choice. *I like apples too! We like apple.* <Child's name>, let's pretend we are eating the *apple*. [brings the hand close to the face] munch munch much.
Tablet: [the apple gets bites, synchronized with the robot's drinking motion]
Robot: Mmmm, that was a good *apple. I like apples. I am happy. We like apples. We are happy.* But you know what? *I like apple*, but I like orange, or *orange*, even more!
Tablet: *You love orange* [shows the images of apple and orange again]. *You like apple* [adds a heart around the apple] *and you love orange* [shows a bigger heart around the orange].
Robot: Yes, *I like apple* and *I like orange* more. English uses "*love*" when you like something A LOT. Can you say "*love*" together? *One, two, three… "love*." *I love orange! I like apple and I love orange. I want one orange!* <Child's name>, let's eat the *orange* too! [brings the hand close to the face] munch munch much.
Tablet: [the orange gets bites, synchronized with the robot's drinking motion]
Robot: Alright. What else should we get...
Tablet: *You need vegetables too* [zooms into the vegetable section of the supermarket]
You want one carrot? [shows an image of a carrot]
Robot: Nooooo, *I do not like carrot. I do not want carrot. I am not happy.*
Tablet: *You do not want carrot. But you need carrot.*
Robot: *Need…?* <Child's name>, do you know what the word "*need*" means?
Child: (says something)
Robot: Hmmm, okay… *I do not like carrot*, but I know *carrot* is good for me… I do not want *carrot*, but I kinda need *carrot*.
Tablet: *Do you need carrot?*
Robot: *Yes, we need carrot.*
Tablet: *You want one* [shows an image of a carrot on left] *or two* [shows an image of two carrots on right]*?*
Robot: <Child's name>, *we want one carrot?* Or *we want two carrots?*
Child: (says something)

Robot: Hmm... *I know we need carrot, but I do not love carrot.* So let's just get one carrot. Can you touch the *left* one? Let's say "*we need one carrot*" together! *Three, two, one, we need one carrot!*
Tablet: *You need one carrot.*
[the image of one carrot gets bigger while the image of two carrots disappears]
Robot: *Yes, we need one carrot.* <Child's name>, let's pretend we are eating the *carrot*. [brings the hand close to the face] munch munch munch.
Tablet: [the carrot gets bites, synchronized with the robot's eating motion]
Robot: Oh, I thought *I don't love carrot*, but it is good. *I love carrot!*

Part 2: Testing (3-5 minutes)
Tablet: *Now, please get things for your friends* [shows images of an elephant and a mouse at the bottom of the screen]. *This is an apple* [shows images of an apple at the top of the screen].
Elephant: *I like apple.*
Mouse: *I don't like apple.*
Robot: I think we should give the apple to a friend who likes apple. Can you do that?
Child: {drag and drop the apple to the elephant}
Tablet: [The elephant receives the apple, and both elephant and mouse smile happily]
Elephant: *Thank you!*
Robot: Yay, great job! Give me a five [high five motion]!
Tablet: *This is an orange* [An image of an orange appears at the top of the screen]
Elephant: *I don't want one orange.*
Mouse: *I want one orange.*
Robot: Who should we give the orange to?
Child: [drag and drop the orange to the mouse.]
Tablet: [The mouse receives the orange, and both elephant and mouse smile happily]
Mouse: *Thanks!*
Robot: You are doing great!
Tablet: *This is juice* [shows images of a carton of juice at the top of the screen].
Elephant: *I like juice.*
Mouse: *I love juice.*
Robot: We should give the juice to the one who likes juice more!
Child: {drag and drop the orange to the mouse.}
Tablet: [The mouse receives the juice, and both elephant and mouse smile happily]
Mouse: Yes, thank you!
Robot: Wow, you are do good at this.
Tablet: *Now, here are more friends* [shows images of a cat and a rabbit at the bottom the screen]. *This is milk* [shows images of a carton of milk at the top of the screen].
Rabbit: I like milk.
Cat: I need milk.
Robot: Hmm, which one "*needs milk*"? What do you think?
Child: {drag and drop the milk to the cat.}
Tablet: [The cat receives the milk, and both rabbit and cat smile happily]
Cat: *Thanks!*
Robot: Awesome!

Tablet: *This is a carrot* [shows images of a carrot at the top of the screen].
Rabbit: I love carrot.
Cat: I need carrot.
Tablet: *Which one loves a carrot?*
Robot: Hmm, which one "*loves carrot*"? What do you think?
Child: [drag and drop the carrot to the rabbit.]
Tablet: [The rabbit receives the carrot, and both cat and rabbit smile happily]
Rabbit: Thanks!
Tablet: *These are two apples* [shows images of a carrot at the top of the screen].
Rabbit: I want two apples.
Cat: I need two apples.
Tablet: *Which one wants two apples?*
Robot: Hmm, which one "*wants two apples*"?
Child: [drag and drop the apples to the rabbit.]
Tablet: [The rabbit receives the carrot, and both cat and rabbit smile happily]
Rabbit: Thank you both!
Robot: Nicely done!
Tablet: You are done with shopping
[shows all four animals on screen]
Rabbit and Cat: Thank you for shopping for us!
Elephant and mouse: *Thank you very much!*

Part 3: End of lesson
Robot: Wow, that was great! <Child's name>, thank you so much for playing with me. *I like you.* No, *I love you!*