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The Use of Social Robots for Supporting Language Training of Children

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Abstract. A number of studies have found that robots can contribute to engagement and motivation in educational settings. We wanted to explore the possibilities and challenges of using a social robot as an assistive tool for learning and training of basic concepts and words. Robots are considered promising tools in language training because they can contribute to systematic interaction and repetition. A prototype was developed using an Aldebaran NAO robot combined with pictures that could be presented on a tablet, PC or on the wall using a projector. The prototype was piloted in two pre-projects with different groups of children learning Norwegian. One project targeted second language learners in a kindergarten and the other targeted young primary school pupils with autism spectrum disorder. Both of these groups need more systematic training than they usually get during the normal kindergarten and school schedule. We wanted to study whether and how the use of a social robot could contribute to more systematic training, increased learning intensity, more repetitions and ultimately more effective language learning. In this paper we present experiences from developing, implementing and using the prototype in the two different settings. The prototype is described, as well as the pedagogical settings of the two pilots. We present results from observations of the children and interviews with teachers and supporting personnel. We discuss differences between the two cases and methodological limitations. Finally, we discuss possibilities and challenges of using robots in language learning and training of children.

Keywords. Social robots, child-robot interaction, language training, second language training

1. Introduction

There is an increasing interest in using social robots in educational settings, and particularly for children, since they often seem to be more willing to interact and engage with robots than adults. Robots can provide learners with motivational and personalised support, and thus contribute to engaging learning experiences, and they can provide teachers with new teaching tools [1]. Research has shown that the use of robots can be effective in learning of knowledge and skill-based topics, but there is less research on the effect of utilizing robots in language learning [2].

We conducted two exploratory pilot studies using social robots for language training in Norwegian. The aim was to get to know the technology and its potential as an assistive tool in Norwegian language teaching. One target group was first year primary school pupils with autism spectrum disorder (ASD). It had been observed that for many of the

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children with ASD in the south-eastern region of Norway, the language learning curve would level out, and that they would lag more and more behind their peers during primary school. This could be due to the fact that these children often get less intensive language training and less one-on-one follow up in school than in kindergarten. This combined with reports on the positive results of using social robots for teaching this group social skill, were important motivations for initiating the study.

The other target group was minority language children in kindergarten. There are up to 80% minority language children in kindergartens in the Groruddalen district of Oslo. Children from minority or immigrant families often use a different language at school than at home. Therefore these children start learning the school language later than their peers. Various measures have been taken to improve the language education in these kindergartens. Despite this, about 40% of the children who started primary school in this area during the autumn of 2017 had a need for additional Norwegian language support to be able to attend ordinary education. Most of these children had been in kindergarten for several years before starting school.

For both target groups, the current language training practices seem insufficient. Thorough and good language training in kindergarten and early elementary school could be of great importance to the individual's further education. It also has the potential for significant savings through reduced need for additional language support in further education. The question is therefore whether introducing social robots at an early stage for these two groups could contribute to more efficient language training.

2. Related work

The number of projects that explore the use of social robots in language education is increasing, and many studies find that the use of robots can have a positive effect on attention, satisfaction and engagement [3]. Positive effects from robot-assisted language learning have also been reported, such as an increase in vocabulary acquisition, speaking ability, pronunciation, confidence in learning, and storytelling skills [2,3]. There have been studies on both first and second language learners.

Several studies have also shown positive effects from using robots in education of children with ASD. In particular, positive effects have been observed when using robots for improving social skills. Among observed effects are increased involvement, positive behaviour and social interaction [4–6]. Studies have also reported positive outcomes on vocabulary development and communication skills for children with ASD [3]. It has been argued that social robots may be especially beneficial for individuals with ASD, because the robot may be less intimidating, more predictable and more patient than a human teacher.

In many of the language learning projects the robots have been used for learning English, but studies of learning other languages with a robot, such as German, Dutch, Italian, Spanish, Japanese, Korean and Persian, have also been reported [2,3]. There are, to our knowledge, currently no other study of the feasibility of using robots for learning Norwegian, which is a rather small language. It is a general problem that robots are less reliable in recognizing children's speech automatically than adults (ibid).

While many studies suggest benefits of using robots for language learning, most studies involve relatively few children, are mainly qualitative and exploratory. Due to the lack of long-term studies and experimental studies comparing outcomes with a control group, there are a number of open questions. For example, there is a need for

more research on the long-term effects of using robots, such as whether the use of social robots has an advantage over other digital technologies, and on what qualities of the robot that are important for language learning. There is also a need for more research on ethical questions related to the use of social robots, such as on what effects the use may have on the emotional and social development of the children [7].

3. Approach

To get acquainted with the social robot technology and explore its possibilities for language learning and training, we wanted to conduct two pilot tests. We therefore had to acquire a robot, and did some research and assessments of different alternative robots. Among aspects that were considered were the present learning scenario, characteristics and possibilities of the technology, price, and experiences from related projects. After an overall assessment, two robots of the type NAO developed by SoftBank Robotics (formerly Aldebaran Robotics) were acquired, one for each pre-project.

3.1. The prototype

A prototype was developed for use in the pilot tests. The overall design as well as the content and the interaction mechanisms were developed in collaboration with the educational staff associated with each user group. The procedure was further adapted to the pedagogical approach used in the two different settings.

The prototype was based on a simple language game, and included the robot and a tablet/PC in combination. After a brief greeting and explanation, the robot would ask the user to create a mind map associated with a specific word/term. It would wait in sleep mode while the mind map was created. The mind-mapping was led by a session leader/teacher. Then, the session leader would activate the robot again, and four alternative images were displayed on a display (tablet/PC). The robot would ask the user to point to the image representing the word that was introduced previously. Only one of the images would correspond to the word. Then the robot would ask the user to say the word out loud with a clear voice. In case of incorrect response from the user, or if the robot failed to recognize the word, the user would be encouraged to try again. The robot would "cheer" and give a positive feedback when it recognised a correct answer. After these three activities (mind map, image-selection, pronunciation), the robot would ask the user whether he or she wanted to continue the game, and in that case it would start over again with a new word/term.

3.2. The pilot testing

The pilots were conducted in January and February 2018. Both pre-projects were carried out over a two weeks period. All the sessions were video-recorded by a member of the project team who also took notes. The two pilots are described in more detail in the next sections.

3.2.1. The second language learners in the kindergarten

The use of the robot was integrated in the pedagogical approach that was used in all the kindergartens in the Grorud district of Oslo. The robot-assisted sessions were piloted in

one kindergarten department and were carried out during the daily group gatherings in the morning, with all the children in that department (10-16 children). The sessions were led by pedagogical personnel in the kindergarten. In addition to the plenary sessions there were also two separate sessions with smaller groups of four children. The most important goals of the overall pedagogical approach are:

- Frequent and systematic repetitions
- Short daily sessions
- Learning to organise and categorise words into main terms and sub terms
- Learning about synonyms and antonyms,
- Develop an understanding of the content, form and use of high-frequency words that they are likely to meet in their everyday life and in school
- Develop an understanding of content, form and use of analytical and comparative concepts

In the plenary sessions, all the children sat on the floor along the walls in a half-circle around the session-leader. The robot «NAO» was located next to the session leader and visible to all the children. The session leader also held a tablet where the images were displayed. During the first week, new words were introduced, and these were repeated during the second week.

After a few sessions the tablet was replaced with a projector, so that the images could be displayed on the wall. There were two advantages with this setup. First, the pictures became larger and easier to see for all the children, and second, because the lights in the room were muted the attention was drawn to the images projected on the wall. After the robot posed a question, many children would answer. A person from the staff would use a mouse and point to the picture that the children indicated. Likewise, when asked to say the word out loud, the session leader would repeat the word suggested by the children, and the robot would recognise the word and give feedback as described above. If the robot could not perceive or interpret the word, it could ask the user to repeat the word in a clear and precise voice. The interaction with the robot lasted about 15 minutes, less the time spent on making mind maps.

3.2.2. First year primary school pupils with autism spectrum disorder

The prototype was tested with two children with autism spectrum disorder (ASD) integrated in an ordinary primary school in the Drammen region in South-East Norway, not far from Oslo. It was first tried in a joint session, but because we realised that the two children were at a very different level both with regard to language skills and technology interest, it was decided to continue with each child individually. Each child performed 3-4 sessions during a two week period. The session lasted for about 15 minutes. In the individual sessions, the child would interact directly with the robot by answering directly and using a finger touch to select the images on the tablet. In addition to observation and note-taking, the experiences were also discussed in a focus group meeting with the parents of the two children and the pedagogical personnel.

3.2.3. Analysis

We conducted a qualitative analysis of the videos which also were compared with videos and observations performed in the week before the robot was introduced in the case of the kindergarten. The results were also discussed with the person responsible for the

educational program in the kindergartens. In the ASD case, the videos were analysed, but we did not have comparable videos of sessions without a robot. In this case we had to rely on the discussion of the experiences in the focus group.

4. Discussion and results

Below we discuss the most important experiences from the two pilot studies.

4.1. Engagement and participation

The observations indicate that the robot-supported training had a positive impact in the sense that the children showed interest, engagement and participation. In the kindergarten it seemed that more children participated in the sessions with the robot, compared with the sessions without robot. The analysis of the video recordings also showed an increase in the involvement and participation in the second week than in the first week. More children with minority-language backgrounds and weak Norwegian skills participated in the second week. This may be due to increased familiarity with the technology, but it can also to be related to the way the tasks were made visible.

4.2. Combining tools and elements

Using a projector and muting the lightning in the room made the images of the words easily visible to everyone. This made it easier to get the children's attention. Thus, introducing the projector and muting the light was successful and contributed to a higher level of engagement and participation. This also demonstrates the importance of viewing the training program as a whole, and to explore a combination of different tools and procedures to achieve the best result. Also the experiences from the pilot with the children with ASD showed increased engagement, and to a particularly large extent for one of the children. This also showed that there may be quite large individual differences regarding how the robot is perceived.

4.3. Learning outcomes

The pilots do not provide a basis for clear answers regarding the children's learning outcomes. Due to the short test period and limited resources in these pre projects, we did not measure the learning outcomes. However, the experiences from the tests indicate that a robot-supported scheme has a significant potential. The words were placed in a context, and elaborated with examples using mind maps and images. Further, the robot was used to make the children listen to the word, and to say the word out loud. Thus, we believe that this robot-supported scheme can contribute to language learning by combining different means of communication in a systematic way; by association, visualization, listening (to the robot, the session leader and other children), pronunciation and repetition.

An interesting additional effect in the kindergarten was that the children became skilled in using words like "up", “down", "right”, “left", etc., because they were asked to choose between the four images that were presented in two rows (2*2). When the session leader asked the children to point out the word on the display, they answered for example, "top left”, “bottom right”, etc.

4.4. Need for more robust speech recognition

The selected robot has weaknesses and shortcomings when it comes to voice recognition, in particular when it comes to recognition of children's speech. Initially, we had an ambition that the children themselves should pronounce the words that the robot should recognize and respond to. However, in the kindergarten context we had to depart from this approach, and instead allow the session leader to say the appropriate word to the robot after the children had made their suggestions. One challenge is that the robot does not recognize the answer if there is background noise. Also, it is necessary to speak relatively loud, or you have to be close to the robot. In the individual sessions with the children with ASD, we observed that they often had to repeat themselves because the robot did not perceive the answer.

Moreover, there is a timing issue, requiring the user to answer within a certain window of time after the question has been posed. For one of the children with ASD this was not a problem because he quickly learned when the robot was ready by listening to its sounds and watching the lights in its eyes, but for the other child, this problem also contributed to the need for repeating the answer.

In general, the children were quite patient during this short trial, but we believe that these shortcoming could become frustrating after a while.

4.5. Language issues

Another issue was that the robot did not speech Norwegian optimally. The intonation was sometimes not satisfactory. Also the rhythm and speed of speech had weaknesses. Interestingly, these weaknesses did not seem to have any significant negative impact during the pilot tests. In general, the children could perceive the word, and they seemed to ignore the sometimes odd pronunciation of the robot. They pronounced the word correctly in Norwegian. In the kindergarten case, this may be due to the combined approach, where the session-leader repeated the word to the robot. Also in the ASD case, the children seemed to be able to repeat the words with proper Norwegian intonation. Here the session leader spoke only if the child did not know or say the word correctly. In a more developed solution, however, we believe that it is important that the robot has a clear and impeccable Norwegian pronunciation.

4.6. Session length and group size

Based on state-of-the art, the pedagogical approach in the kindergarten case, and by consulting the expert group in the ASD case, we concluded that around 15 minutes session length would be appropriate. We found that this time-frame worked quite well. The robot training sessions were closely integrated into the existing pedagogical approach in the kindergarten. The robot was therefore introduced in a quite large group (10-16 children). While this worked surprisingly well, we believe that the children with the weakest language skills and those who were most reluctant to participate in the large group would benefit from participating in smaller groups or individually as well. In the kindergarten case there were also two sessions with smaller groups of four children in each of the groups. One of these small groups was selected from children with weak skills in Norwegian. The results from these groups indicate that especially the children with the weakest skills will benefit from more personalized, intensive and repetitive training in small groups, as an additional measure to the large group sessions.

4.7. Personalization and easy to use interface for educators

The pilots have demonstrated that there are huge variations in the children's skills and reactions to the robot. We see a clear need for personalization, i.e. being able to adapt the robot-supported scheme to the level, needs and interest of the individual child. This is also pointed out in other studies. In order to do this, we also see a need for a simple interface for educators so that they can easily make relevant adjustments, e.g. with regard to what words/terms to learn. Most importantly, the children must be given enough and appropriate high-quality exposure to the robot-based training. The children with the weakest language skills are the most vulnerable, but are also those who probably can benefit most from robot-based language training.

4.8. Technical support

We encountered some technical challenges during the trials, such as connecting the robot to the Wi-Fi, and setup with other devices. These challenges were solved relatively quickly due to engaged staff and resources in the project and in the municipality. However, we believe that for robot assisted learning to work smoothly in everyday teaching, it is imperative that the technology is robust, has an easy setup procedure and that there are available technical support. Routines for storage, charging, training etc. are also required.

5. Limitations and outlook

While our results are in line with results from other research, there is a need for further research and development in this area. Because these pilots were parts of quite limited pre projects there are a number of limitations, such as the short period (3-10 session over two weeks), that the groups were small, the lack of a control group, and that we did not perform any objective measurement of learning outcomes.

Also, while there is a potential for further technical improvement of the social robot, we believe that it is important to investigate the role of the robot in the overall pedagogical approach and its ethical implications.

One concern is that too frequent and close interactions with robots might damage the children's emotional and social development, and that this ultimately could lead to attachment problems [7]. We did not observe this type of challenges in these limited tests, but it is important to be aware of this danger. We therefore need to consider the extent of the human-robot interaction and to ensure that the relationship with the robot will not replace relationships with humans. A different, but probably also relevant challenge may be scepticism and unwarranted bias in the educational community towards introduction and use of robots in education and for small children in particular. In the case of language learning, the issue of voice recognition for children is essential. There is also need for more empirical work and experiments to further determine optimal length of sessions, the number of words that should be trained per session, the optimal age for using robots, the means of interaction, efficient ways of personalizing, and efficient ways of combining various elements.

6. Conclusion

Our pilot tests have confirmed that robot-supported language learning has a potential for minority language children and children with ASD in Norway. Through two limited pre-projects, we have identified a number of factors that are of importance for the successful use of robots in this area. These pre-projects have also provided us with a good understanding of the potential and limitations of the technology.

We observed increased participation and involvement in language learning during the trial period. The limited scope of the trials does not allow drawing clear conclusions regarding learning outcomes for the children who participated. Despite weaknesses in the robots speech and speech recognition of Norwegian, this did not seem to have any significant negative effects in the pilot tests.

Based on the experiences, we believe that it is important to view the robot as part of a whole, and to see how various elements can be combined to improve the learning situation. Further, for successful implementation in the future, we believe that it is important that the robot is well integrated in the pedagogical approach and in the practical context in the schools and kindergartens.

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