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The influence of a storytelling robot on recall of a storytelling activity

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Abstract

Children need to remember and learn a lot in their early life. This research is focussed on helping children remember details of a story better. This is done with the help of a SurfaceBot, a prototype developed by the Human Media Interaction research group at the University of Twente. A SurfaceBot is a small robot consist of a tablet and wheels that can show image on the screen of the tablet and drive around. To see what can be done with technology, storytelling and memory there is an overview of the state of the art made. The overview is related to the design in this thesis because it is focussed mostly on how multimedia and storytelling can help children learn and remember. And on how technology can contribute to a storytelling activity. Besides looking at what has done before two interviews were done, one with a primary school teacher and one with a volunteers that does storytelling activity in the Wilhelmina Children's Hospital in Utrecht. The teacher gave tips on how to keep attention from children and the storyteller gave tips on storytelling and how tangible objects can be used during a storytelling activity. From the overview and the interviews, a list of requirements and a first design could be made. The activity is storytelling activity were children listen to someone telling a story. The SurfaceBot is used to emphasizes parts of the story by showing facial expressions, making sounds and move between four drawings on the floor that represent locations mentioned in the story. The activity was evaluated in a class of 26 children in the age of six to eight. The activity was done with four groups in a between groups experiment. After listening to the story, the children filled in a questionnaire. With this questionnaire the difference in recall from the children that listened to a story with emphasizing from the story and children that listened to a story without emphasizing was could be measured. These numbers were statically analysed and the results was that the addition of the SurfaceBot has a significant positive influence on the recall of the children. Since the sample size of 26 children is not big and there could be other influences as well as clarity of the storytelling, reading of the questions to the children, gender, home language this conclusion is not certain.

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1. Introduction

Society is changing from an industrial society to an information and knowledge society [1]. With this change, the need to be able to process a lot of information is growing. Storytelling can be a useful tool in helping transfer information. It can be used as a tool to make better sense of information and to relate it to past experience [2][3]. Besides storytelling, the media richness theory developed by Draft and Engel states that richer media are better to convey messages [4]. Rich media makes use of different media, so a video call is better to convey information because of the addition of gestures in comparison to only a voice call. A message that is better understood is also easier to remember. Instead of using multimedia, this research will test if a robot that supports a storyteller will help convey the story and make sure children remember events in a story better compared to no support of a robot.

This research will continue on an already existing project, the coBOTnity project [5]. The project has already been working with enhancing skills that are needed in a knowledge society through storytelling. The so-called 21st-century skills that are mainly focussed on combining creativity, critical thinking, collaboration, working with technology, and many more [6]. The coBOTnity project developed a prototype called a SurfaceBot. It is a tablet (the surface) inside a framework with wheels underneath. It is able to drive around (for extra information an image on the floor can be used) and it can show different emotions as well as images on its screen as seen in figure 1. The existing prototype was mainly focussed on free play and having children develop their own story with the existing assets of the SurfaceBot [5].

Figure 1: The existing prototype of the coBOTnity project [7]

1.1 Research questions

The research that will be done will be more focused on recall and visual learning because both storytelling and visuals can be used as a tool to educate. If the robot can stimulate the memory, then it will become a very useful educational tool. The SurfaceBot will use storytelling and visual learning as a tool to make children remember facts better compared to only a person telling the story. To be able to complete this research multiple questions should be answered.

The main two ones will be:

How can a SurfaceBot be used during a storytelling activity to make children have better recall of the story?

What is the effect on children's recall of events in a story if a SurfaceBot is used to emphasized events in a story?

Before being able to answer the second question if there is a positive effect on recall the first question needs to be answered. This question is about the design of the activity and will be addressed in the fourth chapter, design. This design is based on literature, interviews and practical decision. The second main research question is an evaluation question. This is addressed in chapter 5, evaluation.

Before the main questions can be answered there are multiple other questions that need answering first. The first two questions will be answered by reading previous research and the conclusions can be found at the end of chapter 2:

What has already been done in the field of robots and storytelling and what are opportunities for research that have not been done yet?
How can storytelling and multimedia help children in learning?

These questions are to have an overview on what has been done and how to implement previous research in the storytelling activity of this thesis. The question about multimedia and storytelling in learning is to know what helps children to remember and what may be more distraction than a help.

The third sub question that is asked, and answered in chapter 3, is:

How can the attention of children be kept during a storytelling activity?
How can tangible objects be used during a storytelling activity?

These questions are about the attention of children during a storytelling activity. This is needed to make sure children will pay attention during the storytelling activity. The way tangible objects can be used is relevant because the SurfaceBot can serve as a tangible object. Most actions that can be done with tangible objects can also be done by the SurfaceBot. These two questions will be answered by doing interviews in chapter 3.

1.2. Background

To start this thesis there is some background information needed. First the definition of storytelling will be discussed and after that the functionalities of the SurfaceBot.

1.2.1. What is storytelling

There are a lot of different definitions of storytelling. A few will be highlighted. The first definition is the definition of the national storytelling network of the United States of America [8]. They define storytelling as follows: "Storytelling is the interactive art of using words and actions to reveal the elements and images of a story while encouraging the listener's imagination." A story consists of multiple important parts or events. Firstly storytelling is interactive, it is supposed to involve a two-way interaction between a storyteller and one or more listeners. The responses influence the telling of the story and in contrast with theatre there is no 'fourth wall'. Secondly, storytelling uses words. Language distinguishes storytelling from most forms of dance. Thirdly storytelling uses non-verbal actions. Such actions could be physical movement and gestures. Fourthly storytelling presents a story. It always involves a narrative. And lastly, storytelling encourages the active imagination of the listeners. The listeners imagine the actions, characters and the events of the story. This means that the completed story only happens in the mind of the listener [8]. The definition of the national storytelling network of the United States of America is in some ways different than others. Agosto [9] has a slightly different definition of storytelling. He defines the difference between storytelling and story

reading. With story reading you are allowed to hold a book in front of you. With storytelling, the story should be more spontaneous, either by memorizing characters or events or freely telling the story [9].

Both do agree that storytelling is an interactive activity with at least two real persons involved. Baldwin and Ching [10] have a different definition and add digital interactive storytelling to it. They define interactive storytelling as follows, "Interactive storytelling presents content in a narrative form with options for users to click and explore different paths for more information. With interactive storytelling, readers are presented with compelling graphics and the choice to click on hyperlinks and multimedia for additional information. Interactive stories include features (dynamic presentation, data visualization, multisensory media) that provide a non-linear path for users to interact with the narration." [10] They do agree that storytelling should be interactive, but the difference is the use of words in a storytelling activity. With digital storytelling no one reads words aloud, but the message is conveyed with the help of written word, images or small clips.

A different approach is to include other activities in the broader term of storytelling. For example, children playing and more specific, pretend play. Pretend play is defined as play that includes the use of fantasy and make-believe, and the use of symbolism [11]. The five aspects of storytelling defined earlier can mostly be applied to pretend play. The child often talks during pretend play but there is not necessarily an audience. So two-way interaction is not always present in pretend play. With all the different views on storytelling, there is one conclusion to be made. The definition of storytelling is very broad, but the general understanding is that storytelling uses words to convey a story and more than one person should be involved in this activity. Most definitions agree that storytelling should be interactive. If the audience reacts in an unexpected way the story should be adjusted according. However, in this research this will not be done. If interactions are a big part of the storytelling activity no story would end up the same, thus there would be more influences on the results.

1.2.2. SurfaceBot

The prototype that is used in this research is called a SurfaceBot. The SurfaceBot is the prototype from the coBOTnity project at the University of Twente. The systems used, consist of two tablets, a base, a router, and a Zumo robot for Arduino. It relies on Robot Operating System (ROS) to support the communications between them. The base, Zumo robot and one tablet form what can be seen as the robot. It can move around, show facial expressions, and play sounds. The other tablet is the control unit, also called the master. This table runs the roscore, this is needed for the ROS to be able to run. Figure 2 represents the structure of the architecture of the components. [7]
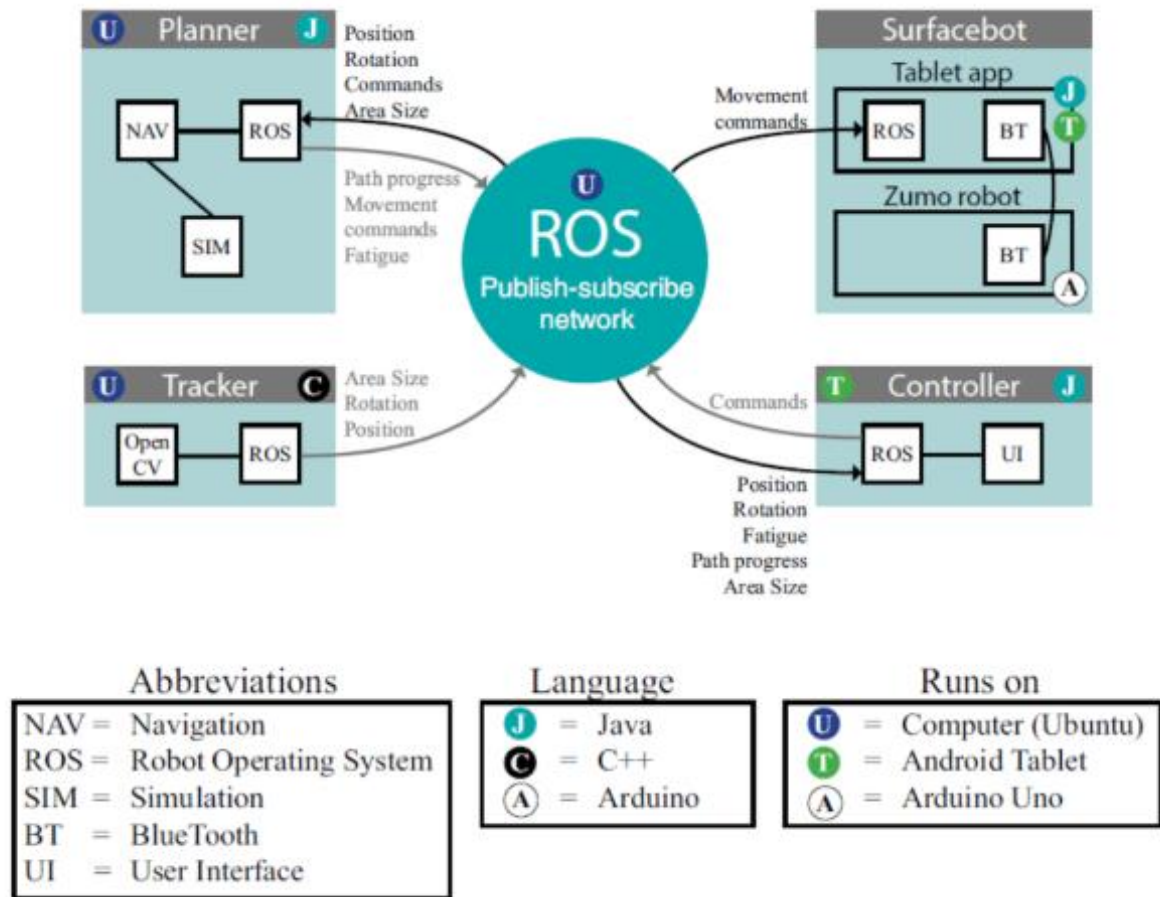
Figure 2: Diagram representing the architecture and structure of the components [7].

It is developed as a distributed storytelling interface for digital support in creative storytelling activities [12]. It is mainly focused on active participation of children during a storytelling activity, but it could be used in various ways.

The control panels can be seen in figure 3.
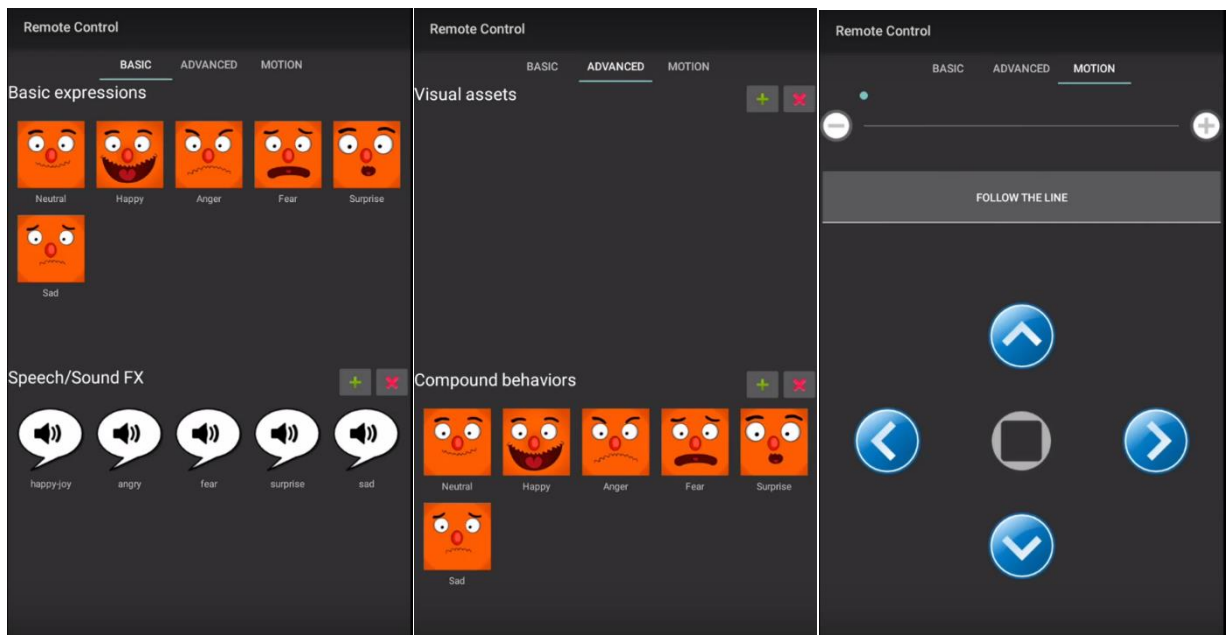
Figure 3: Control panels of the SurfaceBot [7]

These control panels are on a different tablet, the master. There are three different controls: basic, advanced and motion. The basic controls are basic expressions and playing sounds. The advanced controls are displaying visual assets on the screen of the SurfaceBot and facial expressions where at the same time a sound of that emotion is played. The motion controls are about moving the SurfaceBot, the speed and the direction can be controlled.

1.3. Process

To be able to answer the questions stated in the introduction, multiple steps should be taken. Firstly, the first sub question should be answered. This was done by researching what is out there and what not to see what option there are to improve. This can be found in chapter two. After the state of the art two interviews were held, one with a teacher and one with a storyteller. The teacher gave tips on how to get and keep attention of children. The storyteller gave tips on how to tell stories and especially telling stories with the help of tangible objects. After this first step a list of requirements and the first design of the activity could be made. The development and design of the project was done according to the creative technology design process. This model is developed by Mader to define how in the study Creative Technology a student should design and develop a system [13]. It describes three phases; Ideation, Specification, and Realisation. All the phases can be found in chapter 4 Design. Lastly the evaluation was done. First designing the evaluation, after carried out the experiment and lastly evaluation the results of the experiment. This can be found in chapter 5 Evaluation. To dive deeper in the ethical side of the thesis a reflection report was written, this can be found in Appendix G.

2. State of the Art

This chapter will answer two sub research questions. What has already been done in the field of multimedia systems and storytelling? This will start with an overview of systems where children are making a story and later, with the help of technology helping to tell a story to children. A part of the first question is also what has not been done yet, this will be answered by looking at the mentioned systems and seeing a pattern on what is missing. This to see why this research is novel. The second research question is about how visuals and storytelling can help learning in children and what are the best ways to convey a message using multimedia systems and storytelling.

2.1. Storytelling with technology systems, children create the story

There have been multiple studies on storytelling and technology. Most research is focussed on children using multimedia systems, robots or other technologies as listeners or using the system as a toy to spark creativity. In both cases, the children are making up the story. Most of the systems show what can be done when letting a kid create the story. The research is focused on using storytelling as an educational tool. The systems mentioned are generally not robots, they cannot make decision autonomously, but they show how technology can contribute to a storytelling activity. This is what makes them interesting for this research.

2.1.1. Dolltalk

Dolltalk is a toy that was developed by Vaucelle and Jehan [14]. The aim of the toy is for a child to tell a story. The toy will record and play it back to the child with an altered voice. The reason for this is that the researchers found that if a child hears its own story it can understand what makes a good story and that children can be their own critics. Because children move a doll when it is supposed to be speaking the system records when it is lifted from the ground and stops when it is put down. When the story was played back the child often reacted surprised as if someone was in the room listening [14]. Two dolls of the system can be seen in figure 4.

Figure 4: Dolltalk 2001 [14].

2.1.2. StoryToy

StoryToy is an interactive storytelling toy developed to make new forms of playing in the physical world instead of only video games [15]. The system consists of a farm with a few animals and a few sensors. The farm can be seen in figure 5. The system senses where an animal is placed inside the farm and can react to that. The system has three types of play: free play, reactive play, and linear stories. Free play means that the child can freely interact with all the animals without the interference of the technology. Reactive play is a form where the system reacts to actions of the child in the most basic form. This means that when a child picks of the cow the sound 'moo' is played. In the linear story a story is told and at the end of each storyline,

an animal is explicitly mentioned. The child must pick up the animal. If this is not done at all or incorrectly, the system will notify the child with remarks such as 'that is not a sheep' or 'I am waiting.' The system is mainly focused on helping children with making their own stories and is focussed on young children from the age of two to six [15].

Figure 5: User interface of StoryToy [15].

2.1.3. StoryMat

The StoryMat is a playmat that is focused on a system being "child-driven", a toy that listens to children instead of only talking to them [16]. When children tell a story on top of it, it will be recorded. The system records their narration voices and associated movements of the toy. The recorded story is then compared with other stories that share similar patterns. The StoryMat recalls a similar story as a moving shadow of the toy with its narrator's voice. When the mat is done, the child will continue with its own story and will continue taking turns with the StoryMat as if it was a child. Children that took turns with the StoryMat had a story with more diverse language than pretend play and they interacted with the mat as if they were playing with a playdate. This means that playing with a multimedia system can improve certain skills. Some even took on the role as narrator to place the story of the mat into context. Overall it enhances the children's experience and keeps them more focused on the task [16]. A child that is playing with the StoryMat can be seen in figure 6.

Figure 6: A child playing on StoryMat [16].

2.1.4. Tabletop

There are multiple tabletops but in this thesis only one will be discussed because this one is specicly focussed on a storytelling activity and making a story world visible [17]. It is a multi-user interface that uses AI techniques to stimulate social interacting next to the 21st-century skills storytelling can achieve. The children all had one character, or 2 children cooperated on the same character. They took turns in playing out a story. The tabletop recognized the action and gave options the child could choose from. The tabletop stimulated collaboration, creativity, and goal-oriented thinking. The children played in pairs which meant that if one of

the two had trouble with something the other would help. The system had no goal set, but the children started to set goals for themselves, inside the story but also with the tabletop. For children, this stimulates being more goal-oriented [17]. Two children playing with the tabletop can be seen in figure 7.

Figure 7: Children interaction with the tabletop [17].

2.1.5. GENTORO

GENTORO is a system that is develop so that instead of only reading a story aloud, children could create their own story and express it visually and aurally. It focusses on enhancing children's creativity and imagination [18]. The system has three processes, story design, story rendering, and story expression [19]. In the story design process children brainstorm and discuss themes, plots and characters. One main character will be played by a physical robot. In the story rendering process children draw detailed sketches and specify the actions of the robot. In the story expression process the children will manipulate the robot and express their story via a handheld projector that projects graphical images as story scenes. In figure 8 students can be seen that are creating and expressing a story using GENTORO [19].

The research and the system are not focussed on supporting the story design process but is mainly focussed on the novel features of the system, where children could express their story more visual with a handheld projector and a robot that moves through the projected landscape [19].

Figure 8: Students create (left) and express (right) their story by using GENTORO [18].

2.1.6. PETS

PETS is a Personal Electronic Teller of Stories, a robotic storytelling environment for elementary school-age children [20]. The kit contains a box of stuffed animals and an application on a PC. Children can use parts of

the stuffed animals to build their own robotic animal. One of such a creation can be seen in figure 9. After they build their own animal they can write and tell a story using the provided software. When the story is written and there are emotions mentioned the robot can show them by performing a sequence of physical movements. This way when the software plays the story the robot will contribute and perform it. The child is always in control of changing the story and there is no limit on what to write. [20]

Figure 9: A constructed animal made with PETS [20]

2.1.7. Discussion

The already existing systems show that children can be stimulated in multiple areas depending on the focus of the system. A lot of the systems show how technology can make the play experience more fun and also that it can improve what and how children are learning. A lot of older researches have the systems disguised as a stuffed animal. No system really discussed this but the newer ones show a lot more the technology. And have a screen. This may be because technology is a lot present in our lives A lot of the mentioned systems are relevant because they researched how storytelling could be more educational or used as a fun educational tool. This research has that same goal and aims at having storytelling supported by a robot as a tool for remembering more information.

2.2 Robot as a storyteller

Most research has been done on a robot listener or a system that gives reaction to a child telling a story. This thesis is more focused on someone telling a story to a child. So, the next part is about a robot as a storyteller instead of a listener.

2.2.1. Human Robot Collaboration

Yan Wu et al conducted a research twice [21][22] where they researched Human Robot Collaboration (HRC) in storytelling. The first test was a pilot test and later they conducted a second one. In both tests the demographic of the group was similar: all girls of ages 14 and 15. A Nao robot was used which used gestures and it could turn his head to simulate eye contact. With each character of the story Nao used a different voice. The research had two setups: One where the story was told by a robot only (RO) and one with HRC. In the HRC setup, the human storyteller and the robot told the story together where the human told most of the story and the robot was used as a sidekick that did some voices and gestures of the characters. The results of both these tests were that 90% or more found HRC more enjoyable, easier to follow, and thought it was a good way to convey a story [21][22]. With this information, it can be concluded that in this research the robot should not be used as the only speaker but more as an addition to someone that is telling the

story. The SurfaceBot cannot be used with gestures but unlike the Nao, the SurfaceBot is able to show emotions, so it is able to connect with the audience. A scene of one of the experiments can be seen in figure 10.
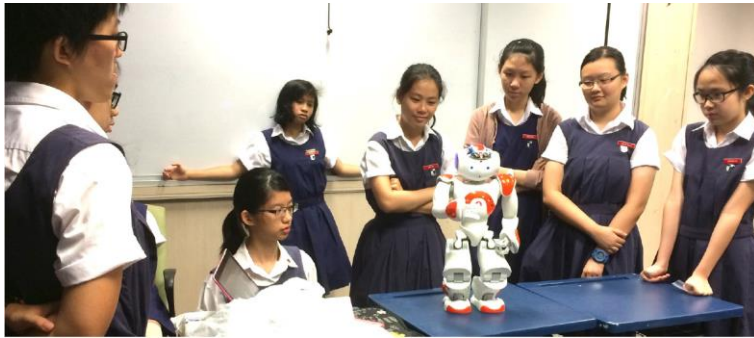
Figure 10: Scene from experiment session setup in the Human Robot Collaboration research [22].

2.2.2. The robot as storytelling partner

Shih et al [23] developed a tool for teachers to use a robot in a foreign language class during storytelling. The aim of this tool is that storytelling can be a useful way to contribute to learning a new language and make teacher more comfortable using storytelling in their classes. This because teachers do not want to spend a lot of time searching for a story with the right difficulty and they are unsure about their skill in telling a story in a foreign language. A storytelling activity is often fun and makes students feel comfortable. Students tend to only speak a foreign language in class when they are comfortable, so storytelling can contribute to multiple skills in the classroom. The project develops a robot interface for teachers where teachers can easily develop their own robot that tends to their needs as a robot assistant. The robot can both be used for its movements but also for playing multimedia.

2.3. Qualities of social robots

There has been a lot of research done on different social robots. The only thing that is relevant for this thesis is how people can feel connected to a social robot. This way it can be implemented in the SurfaceBot and make sure people want to listen and pay attention. A research done by Konok et al [24] looked at human's best friend, the dog, and robots. The research looked at different attitudes towards robots and dogs and found that in service robots people understood how a robot could replace a service dog in all the technical aspects but were not able to see a robot replacing the emotional aspects of a dog. This difference of attitude is mainly because most robots do not show emotion, personality, or attachment. The recommendations for making robots in the future is to implement those qualities more. This way people would connect more to a robot. In this research people also need to connect a bit to the robot so they continue looking at it. Personality and showing attachment will not be implemented, because this is not in the scope of the research, people need to pay attention for a short amount of time but do not need to feel attached.

2.4. Use multimedia in learning

Multimedia learning is closely related to this thesis. The research that is done in that field is relevant since in this research multimedia will be used so it can be beneficial to support recall of a story. Remembering events from a story is closely related to learning.

2.4.1. Visuals in learning

Most visuals that are used in learning are graphs, diagrams, and photographs. For some people having the subject matter visualized is the ideal way of learning while for others it does not make a difference of even find it distracting [25]. A large part of our sensory cortex is devoted to vision, so it makes sense that learning with visuals will help [26]. Almost every specialized study conducted on visuals and learning has emphasized the positive effect on memory, motivation, and performance [25]. Although in this thesis graphs or diagrams will not be used it relevant to know that images can have a positive effect on learning and memory.

2.4.2. Cognitive theory of multimedia learning

The cognitive theory of multimedia learning by Mayer [27][28] assumes that humans process information with dual channels for visual/pictorial and auditory/verbal processing [28]. Each channel has limited capacity for processing, and active learning involves carrying out a set of cognitive processes during learning. The processing of pictures happens mainly in the visual channel, and the processing of spoken words happens in the verbal channel. However, processing of printed words happens first in the visual channel and moves to the verbal channel. The multimedia principle states that students learn better from words and pictures than from words alone when they are both presented, students have the possibility to construct verbal and visual models and build connections between them. Words and pictures that are corresponding should be visible at the same time in a close range of each other. This because students need to have them in their working memory at the same time to be able to combine them and make connections. The modality principle states that students learn better from animation and narration than from animation and on-screen text. According to the coherence principle, students will learn less when interesting but irrelevant sounds are added to a multimedia presentation. [27]

2.4.3. Media richness in multimedia

There have been multiple studies done on the media richness theory on multimedia. In this theory the media richness of something says how good that media is in conveying the message. A video call is more media-rich because people can see gesture than a normal phone call where one can only hear a voice. Jackson and Purcell [29] researched Media Richness with hypertext and created four sites. Two rich and two lean on media richness. One described a simple and one described a complex product. They found that most users preferred the websites with richer media regardless of the complexity [29]. Sun and Cheng [30] did a similar research only more focussed on multimedia learning and found that only when the content of the information is equivocal and uncertain media richness had a significant positive effect on learning score while when the content has low equivocality and uncertainty there is no significant positive effect with media richness [30]. This means that it really depends on the class in which it is used if media richness can improve the learning experience.

2.4.4. Discussion

Mayer and the media richness theory are contradicting each other in some ways. Mayer states that students learn less when interesting but irrelevant sounds are added to a multimedia presentation [27]. While the media richness theory states that the richer the media the better it is in conveying a message [30]. In this research a balance is found that there will be more relevant media implemented, like movement but no irrelevant addition that would distract. To determine this there is looked at the main storyline. This is mostly in line with Mayer. The media richness also states that if there is uncertainty there is no significant positive

effect with richer media so having extra irrelevant actions by the SurfaceBot would probably cause uncertainty.

2.5. Storytelling as a mean to education

In education, stories are helpful in supporting the transfer of knowledge. With a story, the information is stored with other related sentences, so it forms a meaningful whole. Statements tend to cluster into subgroups that are stored in memory as separate parts for later recall to form a complete story [31]. Storytelling can help students untangle new information and relate it to past knowledge. Most stories feel relatable to children and without connection information it is cramming bits of information in short-term memory and without context. Bits of information are a lot easier to remember with the possibility to relate it to past experience and knowledge [2]. Remembering happens with reconstruction, instead of remembering complex materials, copying it and having to reproduce it exactly. People select and interpret information encountered in everyday lives and remember it according to their experience [3]. With stories, students are better able to make meaning, through reflection and synthesis. It is the narrative of the story that serves a cognitive function, allowing students to better store information and understand the information, as well as develop coherence about the world [32]. This means that bringing facts in the form of a story makes sure that people will remember the facts more easily because there is more cohesion and information can be connected to other already known facts.

2.6. Conclusion

The questions asked before the literature research are;

What has already been done in the field of robots and storytelling and what are opportunities that has not been done yet?

How can storytelling and multimedia help children in learning?

Those could be answered now, for the first question there are a few conclusions that can be made and used in the continuing of this thesis, namely: a lot of different systems help children tell their own story, stimulate them to be creative. There are fewer systems specifically build to help support a teacher telling a story, in that field, there is more research done what is necessary for a teacher and how it can be achieved. In the situation for this research, the focus should be on Human-Robot collaboration instead of Robot Only, this means that when telling a story, a human and a robot should work together and not that the robot tells the entire story.

For the second question how storytelling and multimedia help children in learning, storytelling helps children with learning because instead of separate chunks of information children are able to connect the information to other information mentioned in the story or their own experiences. Connecting information makes it easier to remember. To answer how multimedia works there is looked at the work of Mayer and especially his cognitive theory of multimedia learning. It states that when students are presented with both audio and visuals they are able to make a connection and thus remembering it better. This occurs only when both are audible/visual at the same time since then both are in the working memory. The theory also states that channels should not be overflown, so no two sounds playing at the same time. The last question that needs to be answered is what works better if the robot would simulate emotions or show images relevant to the story, as Mayer's theory states: If you use visuals they should be relevant, otherwise it's only a distraction

and the student will learn less. So only the most relevant things should happen. With emotions, it is about how connected children feel to the robot. A lot of earlier research masked robots are stuffed animals so there would be more a connected. The SurfaceBot has already a likable face and if it shows emotions people will feel more connected to it. Which makes them listener more closely.

2.6. Requirements

From the literature some requirement could be made

- The activity should be done with both a Human and a Robot
- Actions of the SurfaceBot should be relevant
- The SurfaceBot should have a friendly appearance
- The SurfaceBot should show human characteristics so people feel connected.
- There should not be more actions of the SurfaceBot than necessary.
- The SurfaceBot should focus on recall of parts of a story in children

These requirements are made from the information provided by the literature and will be implemented in the final activity.

3. Interviews & Practical decisions

To gain more information on storytelling and children two interviews were held. The interviews will provide the answers to two sub question:

How can the attention of children be kept during a storytelling activity?

How can tangible objects be used during a storytelling activity?

One of the interviews is held with a first-grade primary school teacher. This interview is more focussed on the first question. The other interview is held with a storyteller that volunteers in the Wilhelmina children's hospital in Utrecht. This interview is more focussed on the use of tangible object during a storytelling activity. With the information gained a list of requirements was made for the SurfaceBot.

3.1. Interview school teacher

The first interview was done with a first-grade primary school teacher. She has already some experience with the SurfaceBot so it is useful to interview her because she might have some ideas on how to use the system as a learning tool with storytelling. She also has a better insight on what subject matter could be useful to cooperate in the story. Below you can see the questions and the answers.

What does help children to keep them focused during a storytelling activity?

To help them focussed during the story it would help to tell them beforehand that they also are supposed to learn something. So they should listen to the story and not only watch the robot. Besides a clear learning goal, it also helps to be concrete and show things to children.

What would be a good subject for a story for school going children focused on education?

The subject of the story depends a lot on the age. Ages four to six are mainly focused on language, writing, and calculations. Kids start with history at age ten so that would be with older students. For most ages, a story about animals and the way they live would be suitable.

How do children react to stories?

Most children enjoy listening to stories.

Any other tips?

For a test at the end; a recall test with pictures children need to lay in order, have them make a drawing or a mind map to see how much they remember at the end.

3.2. Interview storytelling volunteer

The second interview was done with a storyteller. He volunteers in the Wilhelmina children's hospital and has a storytelling club that tells stories to each other each month. His knowledge is relevant because he tells stories to children with the help of tangible objects and knows what works with using stories to cheer children up and to educate them. For example a story about traveling around the world where he talks about different cultures. He now is developing a small theatre piece that starts with interactive questions about Africa and continues with a story that takes place in Africa. Because of his experience with telling stories to groups of children and keeping their attention this interview was focussed on the way to tell the story to make it fun and that children still can keep their attention. Besides that, there was also focus on the content

of the theatre piece he is working on and if I would be able to use it. Below you can find the questions and answers to the interview.

What kind of stories do you tell?
He is now developing his own theatre/storytelling activity. It begins with an educational activity and later tells the story of Nungu and the Elephant. It is based on the story *"Nungu and the hippopotamus"* (1980) by Babette Cole. The story follows a clear path so it might be useful for the project. The story is told in a way that it starts at location A and the protagonist travels to location B and C to go back to location A. In the activity of this research the SurfaceBot could follow that same path. The locations are also easy recognizable in a map.

What kind of tangible objects do you use during storytelling?
For tangible objects, he used mostly hand puppets as characters. With a pirate story, he has a treasure map with him that he shows when he talks about it but hides the moment it is not about that anymore. This because if he keeps the map out children will want to look at it and forget to focus on the story.

Do tangible objects only help to make the story lively or also to keep the focus of the children?
If the tangible objects are in the view of children while they are not mentioned they can be really distracting but if they are used at the proper moment they can make sure you capture the entire focus of a child.

When are tangible objects more distraction instead of an addition?
With tangible objects, you need to take care that they do not take over the story. Not like "now he walks towards the tree" and later move the puppet but make movements and telling the story at the same time. You are the storyteller but if kids are mostly focused on the puppet it is not a bad thing as long as their focus is on the story

Does a visualized story world help to visualize the story?
He thinks about the same way as a treasure map or a puppet. It can really help to spark the creativity in children because they can visualize the story world more easily. Besides creativity it can keep attention and focus more on the story.

What are important do's and don't's while telling a story to children?
It is really important to practice telling the story. Know it by heart so when a child reacts differently you can respond accordingly and not be forced to stick to your own story because you otherwise will forget it. Children can react differently than you expect so you need to be ready for that.

You also need to be enthusiastic, if you tell a story with enthusiasm children will listen to it more attentively and become enthusiastic themselves. Be convinced of your own story and have interaction with the audience. This keeps them awake and focused. In his experience, the use of puppets also helps to keep focus.

-

3.3. Requirements based on the interviews

From the interviews and the practical decision a list of requirements for the activity could be made. In the interviews there is talked a lot on how not too distract children during a storytelling activity, the following requirements are about that.

- State a clear learning goal for children before the activity
- Be concrete while explaining the activity
- Be enthusiastic during the activity

There were more questions about tangible objects, so the following requirements are related to that.

- Make movement while telling the story. Do not pause too long for an action of an object
- Use object during a storytelling activity only when they are relevant

4. Design

In appendix F there are two persona and a scenario to get familiar with the target group and the situations the system may be used in. From the requirements based on the literature and the interviews a start of the design of the activity was made, this will be discussed in this chapter. First the details of the story are given in 4.1. In the story are multiple locations mentioned. The design of these locations is discussed in 4.2. The actions the SurfaceBot will execute are discussed in 4.3.

4.1. Story

In the interview with the storyteller, he talked about his own project and that it may be useful for the activity in this thesis. He uses the story of Nungu and the elephant. It is an adapted story from Nungu and the Hippopotamus by Babette Cole [33]. The story is about an elephant that drank all the water of a lake and Nungu tries to find the elephant to make it hiccup and pour all the water back into the lake. The story is in Dutch and can be found in Appendix A. It follows a clear path that can be followed by the SurfaceBot. It has clear locations that can be drawn on a map. Although it is not a story with part of the curriculum of the children incorporated, it has multiple locations and to have a story with that incorporated there needs to be a new story written which is not inside the skillset of the researcher. Two storytellers and a teacher were asked for story recommendations but no one had real tips on finding a suitable story. Other resources as the internet were used. After some time of searching no suitable story was found. Since the research is about if children can remember parts of a story better, it was preferred to have a story with part of the curriculum but not necessary.

Some small changes have been made to the story: more emotions have been explicitly written down and some sentences were rewritten so the sounds were mentioned at the end. The emotions are added in place were they were implicit.
For example the original was:

Grandpa said: 'Nungu, when I was your age I swam in the lake, went fishing and sailing with my kano. But now there is no more water...'

That was changed to:

Grandpa said with a tone of sadness: 'Nungu, when I was your age I swam in the lake, went fishing and sailing with my kano. But now there is no more water...'

In the original sentence it's implicit that his grandpa is sad because there is no more water but with adding the word sad it makes it easier to understand.
To exclude a lot of variety in the story, the storyteller will read the story instead of telling it by heart. This is in contradiction to the definition of storytelling. It is more story reading since the entire story is in front of the person telling the story.

4.2. Locations

In the story four main locations are mentioned. The village, the wood, the river and the lake. The first sketch of this can be seen in figure 11. It is a smaller sketch than the original would be. It is a map like idea where the SurfaceBot could drive around on top.

Figure 11: The first sketch of the map

For the activity a teacher was contacted and she agreed to do the research with her class. On the visit to the school the locations of the activity was made clear. It was uncertain exactly where, this because of weather reasons. Because of the uncertainty of the location the decision to make different images instead of one big one. This way the size of the activity would be resizable to the location. With this decision of making four separated images the idea of making front view instead of top view rose. This way the locations could be more detailed and be more inside of the story. It is easier to imagine being somewhere when you have a side view picture instead of a top view. When asked to a few students (three) all of them agreed that for children with four different images it would make more sense to have a front view instead of a top view. Students were asked because there was no access to children available. The idea changed from a map to four different front views. Four different locations were drawn, see figure 13-15. When asked five different students what they saw most answered the village, the woods and the river somewhat correct. One thought the river looked more like a lake because of the still water. The lake however looked more like a sea instead of a lake. So the mountains in the background were added to the lake image, but the lake was still not really clear. It was too square so an entire new image was made, see figure 16. For the river, some scribbly lines to indicate flow were added, see figure 17. There is no picture of the first version of the lake only of the first version of the river. On the image of the forest and the village there were no comments, they were clear enough. The versions are shown below.

Figure 13: The first and final version of the forest location

Figure 12: The first and final version of the village location

Figure 14: The second version of the lake location

Figure 15: The first version of the river location

The lake and the river changed to:

Figure 16: the final version of the lake location
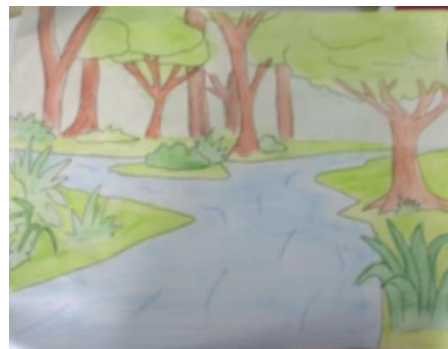
Figure 17: the final version of the river location

When asked the same question to different students what the locations represent everyone answered similar to the correct locations and as comments, only compliments on the drawing were made. So it was decided that these four images would be the final versions for the activity.

4.3. Actions

The SurfaceBot will perform different actions during the storytelling activity to emphasize certain events in the story. First the idea was to only show facial expression and no visual assets on the screen of the SurfaceBot. When later there was looked at this feature to be added as an extra there was a bug in the system. This resulted in the final result to not included visual assets. The controls of the SurfaceBot were already made by the CoBOTnity project, in this thesis nothing has been adjusted in the controls. The controls are easy to understand but harder to execute. So the persons that told the story was not able to tell the story and control the SurfaceBot. So there was chosen to do the activity with two persons. One that controls the SurfaceBot and one that tells the story. The story has two main characters but since there is already one person extra needed for telling the story there is chosen to have one SurfaceBot representing both the characters. Two SurfaceBots also may be more distracting and adding irrelevant distractions.

4.3.1. Sounds

As an addition to the story, the SurfaceBot will play some sounds. Inside of the story there are not a lot of events that would be good to support by sounds. There should be no unnecessary actions added. The first design had more different sounds. When performing this option it felt less as support and more of distraction because the mentioning of the sound in the story was not at the end of a sentence which means you either had to take a break in the middle of the sentence or play the sound at the end of the sentence when it was not relevant anymore. Even if those sentences were changed it did not felt like it was a good support. This

led to the decision to have three sounds. When the elephant swallows the lake a swallowing sound is played. When the elephant swallows the medicine there is also a swallowing sound and when the elephant hiccups to spill the lake a hiccup sound is played. When performing this in front of two students this seemed as too few sounds so there was one sound added. There is a point in the story where the main character, Nungu, is waking up because of nightly animal sounds. Nungu is afraid here and continues his journey. A nightly animal sound is also added to the activity. The sounds are from a site https://freesound.org/ here all the different sounds could be found and are free to use.

According to the literature [27] sounds can have an effect of clashing channels because instead of listening to the story children also listen to sounds that they do not expect nevertheless ther I chose to use sounds in the activity. This because when children are not paying attention they would not notice a different face on the screen because they are looking somewhere else. When playing a sound children will hear this and hopefully focus back on the activity. So sounds helps in maintaining or getting the attention back.

4.3.2. Facial expression
The emotions that will be shown are; Sad, neutral, fear and, happy. Those emotions are a part of the story and they enhance that participants feel connected to the SurfaceBot and emphasize parts of the story. The face is the already developed face for the SurfaceBot, it's a friendly face and has already been tested on children. The images of the face can be seen in figure 18. A facial expression will be displayed when an emotion is mentioned. In this way children can also see the emotion on the SurfaceBot instead of only hearing the word for it.

4.3.3. Movement
The four locations are spread out across the ground. It was tested how far apart they should lay. While telling the story there is more time to go from the river to the village then from the village to the lake. The speed of the SurfaceBot can be adjusted so the distance is in relation to the other locations. The woods and the river should be a bit closer to each other and so should the village and the lake. After moving the front of the SurfaceBot should always face the audience. Movement is done to emphasize the traveling from location to location in the story.

4.3.4. All actions
With all the actions combined here follows a list of all the actions that are executed during the story. The sounds are played after the end of the sentence in the story so there is a small break and there will be no two sounds at the same time. In appendix E a table of all the actions of the SurfaceBot can be found. To have visual representation of what when happens in figure 18 it is displayed what happens in which minute.

Time	First minute			Second minute		Third minute		Fourth minute			Fifth minute
Face	😐	😐	😐	😐	😐	🙁	😐	😐	😐	😐	😄
Emotion	Neutral	Sad	Neutral	Sad	Neutral	Fear	Neutral	Sad	Neutral		Happy
Sound		Swallow				Night			Swallow	Hiccups	
Movement			↓Forest		↓River		↓Halfway	↓Village	↓Lake		

Figure 18: A overview of all actions during the activity

The timing of these actions are mostly based on the story itself. The controls are done by hand so during the activity the controller of the SurfaceBot read the story along side the storyteller and looked at when an action should be done. This was marked on the paper with the story with different colours to be sure what when needed to be done.

5. Evaluation

This chapter describes the evaluation that was done to answer the evaluation main research question. This question was about whether the SurfaceBot had a positive influence on recall of a story or not. First the method will be described, who participated, how the procedure went and the hypotheses.

5.1. Method

This subchapter is devoted to explaining the participants and the complete experiment with the different steps involved.

5.1.1. Participants

Class 3/4 of primary school "RKBS De Regenboog" was willing to participate in this research. The children in this class are aged six to eight years old. This group is chosen because of availability but the age of the children is well suited for the activity because they are old enough to understand most words and can read for themselves, but they are not too old to think listening to a story is boring and would therefore not pay attention. Because the participants are children consent was needed from their parents, see appendix C. To give parents more information about what their children were going to do an information brochure was given, see appendix D. Parents were given the option to participate without permission to publish imagery in a report or presentation, or to participate with permission to publish photos and/or video. Every parent that handed in the form gave permission for participation, not everyone did for publishing photos and/or video.

The class consisted of 28 children. Two of them did not hand in the consent form so 26 children could participate. The testing was done in four groups. In the class there are both children in grade three and four but for the experiment they will be tested separately. The experiment is designed to test between subjects, no participant did the activity twice. There were two groups of seven children from grade four and two with six children from grade three. Two groups were control groups and heard the story without the robot. Two groups heard the story with the support of the robot. During the activity, the rest of the class did something with the teacher in the classroom while the testing took place in the playroom, which was a separate room.

The teacher made the groups and in some groups more girls than boys were present. In grade three six girls heard the story with the SurfaceBot and no boys did. The group without the SurfaceBot consisted of two boys and four girls. In grade four six girls and one boy were in the group with the SurfaceBot and three girls and four boys were in the group without the SurfaceBot. This distribution of gender is not equal, but the teacher focussed on distributing the noisy ones, so dividing genders was not taken into account.

5.1.2. Procedure

The morning started with a small explanation in the classroom. The students introduced themselves to the children and explained that the children would participate in a small experiment. The experiment was done by two students, one who controlled the SurfaceBot and one who told a story. Some children would hear a story with the SurfaceBot and some would not. After the story they would be given a questionnaire with some questions about the story.

In the morning the experiment would take place. Every half hour six or seven children entered the playroom. When they entered, they were asked to sit down on a mat of the floor. In such a way that all of the children could see the SurfaceBot, see figure 19.

Figure 19: Children of grade 4 participating in the activity

A small explanation was given, they were told if the robot would be present or not. If the robot was not going to be present there was told that after the research a small demo would be given to them. If the robot was going to be present it was shown what it could do before starting the story. The facial expression, the sounds, and the movement were shown to them. This was done so the children were not distracted when it moved the first time. For more information on the exact details of the activity see chapter 4 Design.

During the experiment the data that was collected were video images. Those were analysed to see if children payed more attention when the robot was moving and whether or not something distracted the children. When something happened and no one answered a question correctly in the questionnaire, then that question could be removed. The other data that was collected was a questionnaire. After the activity everyone that participated got to fill in a form. Since the class had to continue with their daily tasks there was no time for an oral individual evaluation. As evaluation the questionnaire, see appendix B, was read aloud so the children would be able to read along and fill it in themselves. This was recommended by the teacher since not all children are very good readers.

5.1.3. Questionnaire

The questionnaire consists of three demographic questions and nine questions about the story. The first three questions are asked because age, grade and first language of the children can influence how much they understand and remember of the story. The nine questions have different goals, some are about facts from the story that are not emphasized by the SurfaceBot. Those are question 1, 3 and, 4. These are in the questionnaire to check the general understanding of the story by the students. The answers to those questions may also be influenced by the SurfaceBot but this will probably be minimal.

The other questions are about actions the SurfaceBot emphasized by showing emotion, moving to the mentioned location or by playing a sound. Question 2 is about an emotion the SurfaceBot shows. Questions 5, 6 and, 7 are about sounds the SurfaceBot played. Question 8 and 9 are about locations the SurfaceBot rode towards. In appendix E is a table with all the actions of the SurfaceBot and for which action a question was asked in the questionnaire.

5.1.4. Demographics

The first questions of the questionnaire was about the demographics of the children. A lot of the children spoke a different language at home, including Arabic, Kurdish, Turkish, and Russian. In grade four this number was much higher than in grade three. The distribution of the language can be seen in table 1.

	Speaks Dutch at home	Doesn't speak Dutch at home	Total
Grade 3 with SurfaceBot	5	1	6
Grade 3 without SurfaceBot	4	2	6
Grade 4 with SurfaceBot	3	4	7
Grade 4 without SurfaceBot	2	5	7
Total	14	12	26

The other demographic question that was asked in the questionnaire was the age of the children. The distribution of the age of the children can be seen in table 2.

Table 2: Distribution of language and SurfaceBot

	six years old	Seven years old	Eight years old	Unknown	Total
Grade 3 with SurfaceBot	2	4	0	0	6
Grade 3 without SurfaceBot	1	4	1	0	6
Grade 4 with SurfaceBot	0	3	2	2	7
Grade 4 without SurfaceBot	0	5	2	0	7
Total	3	16	5	2	26

Two children from grade four in the group without the SurfaceBot did not answer the question in an understandable way. One answered 210 and the other 218. So the ages of these children are unknown.

5.1.5. Hypotheses

To be able to evaluate the results the following hypotheses were tested. The goal of this research is to see if a robot makes children remember more of a story. There are different stimuli used, each hypotheses tests the effect of one type stimulus. All the hypotheses are tested three times, in grade three, grade four, and in both grades.

1. The SurfaceBot has no influence on the number of correctly answered questions about events not emphasized by the SurfaceBot
2. Children remembered parts the SurfaceBot emphasized with facial expression better than without emphasizing
3. Children remembered parts the SurfaceBot emphasized with movement better than without emphasizing
4. Children remembered parts the SurfaceBot emphasized with sound better than without emphasizing

5.2. Results

The hypotheses are tested. Besides only the hypotheses the overall effect and the influence of home language is also discussed.

5.2.1. Hypotheses results

To evaluate the hypotheses statistics are used. Because the two groups are independent of each other, since it is a in between groups experiment setup, chi Square for cross tables is used to test if there is a connection between the conditions and the number of correct questions. Chi square for cross tables is used. Chi square

for cross tables is used if a problem has two categorical variables. In this case one of the category is With or Without SurfaceBot and the variables are "With SurfaceBot" and "Without Surfacebot". The other category is Number of correctly or incorrectly answered questions. Here the variables are Correct and Incorrect. These two categories with their variables can be put in a cross table or contingency table. Since it about different categories the samples are independent [34].

First hypothesis 1 will be tested. It consists of three parts.
1a. The SurfaceBot has no influence on the amount of correctly answered questions about events not emphasized by the SurfaceBot with children of grade three.
1b. The SurfaceBot has no influence on the amount of correctly answered questions about events not emphasized by the SurfaceBot with children of grade four.
1c. The SurfaceBot has no influence on the amount of correctly answered questions about events not emphasized by the SurfaceBot with children of grade three and four combined.

In the questionnaire 3 questions were asked as a control and those 3 questions will be used to answer if there is a difference or no difference in recall of the story.

1a.
Table 3: Grade 3, question about events that had no emphasizing

	Correct	Incorrect	Total
With SurfaceBot	14	4	18
Without SurfaceBot	9	9	18
Total	23	13	36

As calculated from the information of table 3, the chi-square statistic is 3.01. The p-value is .083. This result is significant at $p < .10$. This means there is a significant difference between the number of correctly answered questions about events that are not emphasized between the control group and the group with the SurfaceBot present.

1b.
Table 4: Grade 4, question about events that had no emphasizing

	Correct	Incorrect	Total
With SurfaceBot	11	10	21
Without SurfaceBot	12	9	21
Total	23	19	42

As calculated from the information of table 4, the chi-square statistic is 0.10. The p-value is .76 This result is not significant at $p < .10$. This means there is not a significant difference between the number of correctly answered questions about events that are not emphasized between the control group and the group with the SurfaceBot present.

1c.

Table 5: All grades, question about events that had no emphasizing

	Correct	Incorrect	Total
With SurfaceBot	25	14	39
Without SurfaceBot	21	18	39
Total	46	32	78

As calculated from the information of table 5, the chi-square statistic is 0.85. The p-value is .36. This result is not significant at p < .10. This means there is not a significant difference between the number of correctly answered questions about events that are not emphasized between the control group and the group with the SurfaceBot present.

There only is a significant difference for hypothesis 1a. The difference between the conditions was significant with children from grade three. This was not the case with grade four or the combination or the two grades. Since there is only a significant difference for hypothesis 1a and not for 1b and 1c, it is not possible to say that hypothesis 1 is correct or incorrect. In grade four there is a small difference visible in favour of the control group. This means that in grade three the SurfaceBot may had an influence on the entire activity and not only on the events that are emphasized.

Hypothesis 2 was tested, it also consists of three parts.
2a. Children of grade three remembered parts the SurfaceBot emphasized with facial expression better than without emphasizing
2b. Children of grade four remembered parts the SurfaceBot emphasized with facial expression better than without emphasizing
2c. Children of both grade three and four remembered parts the SurfaceBot emphasized with facial expression better than without emphasizing
In the questionnaire only one question was asked about this so it is hard to drawing a conclusion.

2a.

Table 6: Grade 3, question about events that had emphasizing with facial expression

	Correct	Incorrect	Total
With SurfaceBot	4	2	6
Without SurfaceBot	2	4	6
Total	6	6	12

As calculated from the information of table 6, the chi-square statistic is 1.33. The p-value is .245. This result is not significant at p < .10. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized with facial expression between the control group and the group with the SurfaceBot in grade three.

2b.
To test this hypotheses 2b the results are put in a table, see table 6. This had a category with a value of 0. A value of 0 cannot be calculated using Chi square so Fisher exact test is used to see if there is a significant

difference between the number of correctly answered questions, about events that in the group with the SurfaceBot are emphasized with facial expression, in the control group and the group with the SurfaceBot.

Table 7: Grade 4, question about events that had emphasizing with facial expression

	Correct	Incorrect	Total
With SurfaceBot	6	1	7
Without SurfaceBot	7	0	7
Total	13	1	14

As calculated from the information of table 7, the Fisher exact test statistic value is 1. The result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized with facial expression between the control group and the group with the SurfaceBot in grade four.

2c.

Table 8: All grades, question about events that had emphasizing with facial expression

	Correct	Incorrect	Total
With SurfaceBot	10	2	13
Without SurfaceBot	9	4	13
Total	19	7	26

calculated from the information of table 8, the chi-square statistic is 0.20. The p-value is .66. This result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized with facial expression between the control group and the group with the SurfaceBot when grade three and grade four are combined.

For hypothesis 2, there was not a significant difference. This was because most children answered the question correctly, maybe the question was too easy for the children. This was also about only one question which makes it hard to be able to conclude anything. So it can not be said with any certainty that the facial expressions of the SurfaceBot did or did not have any effect on the number of correctly answered questions.

The three parts hypothesis 3 consist of are:
3a. Children in grade three remembered parts the SurfaceBot emphasized with movement better than without emphasizing
3b. Children in grade four remembered parts the SurfaceBot emphasized with movement better than without emphasizing
3c. Children in grade 3 and four remembered parts the SurfaceBot emphasized with movement better than without emphasizing

In the story Nungu walks from place to place and to emphasize this the SurfaceBot would move from different images on the ground that represented those locations. In the questionnaire 2 questions were asked about locations. Only one of them is statically analysed since it was a multiple choice question like the rest of the questionnaire. The other question was a question were the children needed to put the locations in

order. The children of grade three did not get the intention of the question and were unable to answer the question. Children of grade four did answer the question but the number of wrong answers was really high. None of the children had the question correct and some had an answer that was close to the correct answer. Since the changes are high that also children of grade four did not get the intention and guessed while answering question 9 will not be used in the research.

3a.

Again a category here has a value of zero so chi square can not be calculated and fisher exact test is used.

Table 9: Grade 3, question about events that had emphasizing with movement

	Correct	Incorrect	Total
With SurfaceBot	4	2	6
Without SurfaceBot	0	6	6
Total	4	8	12

As calculated from the information of table 9, the Fisher exact test statistic value is 0.06. This result is significant at $p < .10$. This means that there is a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized with movement between the control group and the group with the SurfaceBot when in grade three.

3b.

Table 10: Grade 4, question about events that had emphasizing with movement

	Correct	Incorrect	Total
With SurfaceBot	3	4	7
Without SurfaceBot	1	6	7
Total	4	10	14

As calculated from the information of table 10, the chi-square statistic is 1.4. The p-value is .24. This result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized with movement between the control group and the group with the SurfaceBot in grade four.

3c.

Table 11: Combinede grade 3 and 4, question about events that had emphasizing with movement

	Correct	Incorrect	Total
With SurfaceBot	7	6	13
Without SurfaceBot	1	12	13
Total	8	18	26

As calculated from the information of table 11, the chi-square statistic is 6.5. The p-value is .01. This result is significant at $p < .10$. This means that there is a significant difference in the amount of correctly answered

questions about events that in the SurfaceBot group are emphasized with movement between the control group and the group with the SurfaceBot when grade three and grade four are combined.

There is a significant difference observable in grade three and when both grades are combined. In grade four it is not significant but children gave more correct answers when the SurfaceBot was involved. So overall the conclusion on this hypothesis is that the movement of the SurfaceBot from location to location helps recall in children.

Hypothesis 4 was about events emphasized by sound. The three parts it consist of are

4a. Children in grade three remembered events the SurfaceBot emphasized with sound better than without emphasizing
4b. Children in grade four remembered events the SurfaceBot emphasized with sound better than without emphasizing
4c. Children in grade three and four remembered events the SurfaceBot emphasized with sound better than without emphasizing

In the questionnaire there were three questions about events emphasized by sound. They are all analysed together.

4a.
Table 12: Grade 3, question about events that had emphasizing with sound

	Correct	Incorrect	Total
With SurfaceBot	10	8	18
Without SurfaceBot	11	7	18
Total	21	15	36

As calculated from the information of table 12, chi-square statistic is 0.11. The p-value is .74. This result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized with sound between the control group and the group with the SurfaceBot in grade three.

4b.
Table 13: Grade 4, question about events that had emphasizing with sound

	Correct	Incorrect	Total
With SurfaceBot	16	5	21
Without SurfaceBot	11	10	21
Total	27	15	42

As calculated from the information of table 13, chi-square statistic is 2.59. The p-value is .11. This result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized with sound between the control group and the group with the SurfaceBot in grade four.

4c.

Table 14: Combinede grade 3 and 4, question about events that had emphasizing with sound

	Correct	Incorrect	Total
With SurfaceBot	26	13	39
Without SurfaceBot	22	17	39
Total	48	30	78

As calculated from the information of table 14, chi-square statistic is 0.87. The p-value is .35. This result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized with sound between the control group and the group with the SurfaceBot when grade three and grade four are combined.

There is no significant difference in all three of these hypotheses. But when looked at the number of correct answered questions there is a trend that there is were more correct answers in the group with the SurfaceBot. Especially in grade four the difference is almost significant so the trend is visible.

5.2.2. Overall effect of the SurfaceBot support

The sample size in the test is small which makes it hard to be able to be have a significant result. To make this sample size bigger and to have a more overview of the overall effect the questions are combined to see the results from that. First all the questions combined will be tested. In all the different grade combinations. So first grade three, later grade 4 and lastly both grades combined.

Table 15: All questions, grade 3

	Correct	Incorrect	Total
With SurfaceBot	32	16	48
Without SurfaceBot	22	26	48
Total	54	42	96

As calculated from the information of table 15, chi-square statistic is 4.23. The p-value is .04. This result is significant at $p < .10$. This means that there is a significant difference in the amount of correctly answered questions between the control group and the group with the SurfaceBot in grade three.

Table 16: All questions, grade 4

	Correct	Incorrect	Total
With SurfaceBot	36	20	56
Without SurfaceBot	31	25	56
Total	67	45	112

As calculated from the information of table 16, chi-square statistic is 0.93. The p-value is .34. This result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions between the control group and the group with the SurfaceBot in grade four.

Table 17: All questions, all grades

	Correct	Incorrect	Total
With SurfaceBot	68	36	104
Without SurfaceBot	53	51	104
Total	121	87	208

As calculated from the information of table 17, chi-square statistic is 4.44. The p-value is .03. This result is significant at $p < .10$. This means that there is a significant difference in the amount of correctly answered questions between the control group and the group with the SurfaceBot when grade three and grade four are combined.

In grade four the difference is not significant but there is a difference. More correct answers were given by children that got to see the SurfaceBot. In grade three and when the grades were combined, the difference is significant that prove that the SurfaceBot has a positive influence on the recall of children.

To see if there was a bigger effect on questions that were about events that were emphasized. Only the questions about those events are tested.

Table 18: All questions about emphasized events grade 3

	Correct	Incorrect	Total
With SurfaceBot	18	12	30
Without SurfaceBot	13	17	30
Total	31	29	60

As calculated from the information of table 18, chi-square statistic is 1.67. The p-value is .20. This result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized between the control group and the group with the SurfaceBot in grade three.

Table 19: All questions about emphasized events grade 4

	Correct	Incorrect	Total
With SurfaceBot	25	10	35
Without SurfaceBot	19	16	35
Total	44	26	70

As calculated from the information of table 19, chi-square statistic is 2.20. The p-value is .14. This result is not significant at $p < .10$. This means that there is not a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized between the control group and the group with the SurfaceBot in grade four.

Table 20: Emphasized events, grade 3 and 4 combined

	Correct	Incorrect	Total
With SurfaceBot	43	22	65
Without SurfaceBot	32	33	65
Total	75	55	70

As calculated from the information of table 20, chi-square statistic is 3.81. The p-value is .05. This result is significant at p < .10. This means that there is a significant difference in the amount of correctly answered questions about events that in the SurfaceBot group are emphasized between the control group and the group with the SurfaceBot when grade three and grade four are combined.

In both grade three and four, there is a noticeable difference but it is not significant. When the grades are combined the difference is significant. This means that also with only the emphasized events the SurfaceBot has an influence. The influence is smaller than it is with non-emphasized events combined. This means that the SurfaceBot has an influence on the entire activity and not only on the specific events it emphasized.

5.2.3. Influence of home language

A lot of the children spoke a different language at home, including Arabic, Kurdish, Turkish, and Russian. In grade four this amount was much higher than in grade three. See table 2 below

Table 21: Speaking Dutch at home, all questions

	Correct	Incorrect	Total
With SurfaceBot	33	31	64
Without SurfaceBot	31	17	48
Total	64	48	112

As calculated from the information of table 21, the chi-square statistic is 1.90. The p-value is .17. This result is not significant at p < .10. This means that there is not a significant difference in the amount of correctly answered questions between the control group and the group with the SurfaceBot with children that speak Dutch at home.

Table 22: Speaking a different language at home, all questions

	Correct	Incorrect	Total
With SurfaceBot	20	20	40
Without SurfaceBot	37	19	56
Total	57	39	96

As calculated from the information of table 22, the chi-square statistic is 2.45. The p-value is .11. This result is not significant at p < .10. This means that there is not a significant difference in the amount of correctly answered questions between the control group and the group with the SurfaceBot with children that speak at different language than Dutch at home.

Both of these tests are not significant but when looked at the different p-values, it shows that the effect on children that speak a different language at home is almost significant. This can be due to the fact that these children have a harder time understanding the verbal part of the story, and with the visuals they are able to understand. Then it would be more an influence on understanding the story instead of the effect of recall. This difference is small so there is no possibility to say this for certain.

To see if there is a difference in recall between speaking Dutch at home or speaking a different language with no effect of the SurfaceBot the groups are compared to each other. This can be seen in table 23.

Table 23: Distribution of correct and incorrect answers and language spoken at home.

	Correct	Incorrect	Total
Speaking Dutch at home	64 (57%)	48 (43%)	112
Speaking a different language at home.	57 (59%)	39 (41%)	96
Total	121	87	208

As calculated from the information in table 23, the chi-square statistic is 0.1059. The p-value is .744919. This result is not significant at $p < .10$. This means that there is not a significant difference in the number of correctly answered questions between children that speak Dutch at home of children that speak a different language at home.

Because the number of children that speak Dutch at home is not the same as the number of children that speak a different language at home the percentages are used to see if there a difference. The percentages are very alike so there is no difference in recall between children that speak Dutch at home and children that speak a different language at home. The chi-square statistic for the percentages is 0.0821. The p-value is .774469. This result is not significant at $p < .10$. This means that there is also no significant difference between the percentages of the number of correctly answered questions between children that speak Dutch at home of children that speak a different language at home.

5.2.4. Conclusion
The sample size was small, this makes it hard to have a significant result. In all the grades the number of correctly answered questions was higher when the SurfaceBot was present. This difference was only significant in grade three. The overall effect of the SurfaceBot could be seen when the grade were combined. Here both the total of all the questions and only the questions about emphasized events had a significant difference between the control group and the group with the SurfaceBot. Because not a lot of children spoke Dutch at home it was looked into that. To see if that made a difference in answering the questions correctly. This did not have a difference and also not a influence on the effect the SurfaceBot had.

5.3. Video observations
To analyse the video the different actions of the children are observed. Like body language, facial expressions, where the child is looking, and how close the children are to the activity. There are four different videos that are first all observed and the most notable observations are written down. Later the observations are compared to each other.

5.3.1. Grade 3, with SurfaceBot

This groups consisted of six girls. There are multiple observations that can be made. The children reacted the most to the sounds that the SurfaceBot made. They were giggling and somewhat looking surprised around them or at the person controlling the SurfaceBot. If one child would look at something outside or on the ceiling mostly a different kid would also look at that direction to see if there was anything interesting. Of the six children there were 2 children that were most distracted. The distractions did not coincide with parts of the story that had questions about them. The distractions were often but a bit small. The children looked away only for a few seconds. The others looked mostly at the storyteller and at the SurfaceBot and sometimes when moving to another sitting position they moved a little bit closer to the storyteller.

5.3.2. Grade 3, without SurfaceBot

This group consisted of two boys and four girls. At the end one girl asked a questions about the main plotline of the story seeming that she did not understand the story that well. Some children changed their position during the story and one child positioned herself more to the back from where she started. One girl was wearing a shirt with glitters on it and she showed it during the story at the two girls sitting next to her. This happened when in the story Nungu was talking to his grandpa. This was not a part where questions were asked about.

5.3.3. Grade 4, with SurfaceBot

This group consisted of six girls and one boy. The main observation in this group was that they came a little bit closer during the story. Some children more than others, see figure 20. If a sound would play they would all look up a bit giggling or even pretend to swallow themselves while the swallowing sound was playing.

Figure 20: Grade at the start and at the end of the activity

5.3.4. Grade 4, without SurfaceBot

This groups consisted of three girls and four boys. As in the other groups a few kids were more restless than others. In this group two boys and a girl were the most restless. They looked around a lot or even made funny faces and signs towards the camera, see figure 21. The faces they made took over 20 seconds this happened when in the story Nungu found the elephant. There was a questions about this asked. In this group three children answered that question correct while in the other grade four grade only one answered this questions correctly. This probably had not a big influence. Right before the ending one child would even lay down back and showed no interest at all.

Figure 21: A child making funny sign towards the camera

5.3.5. Conclusion and overall observations

In all the groups the children that sat in the middle were the most restless. This probably because there were more distractions of the other children around them. Overall the groups that were doing the activity with the SurfaceBot seemed more into the story and be more focussed compared to the children that only listened to the storyteller. The sounds the SurfaceBot made were clearly attention captures. Every time a sound was heard the children looked a bit surprised and were smiling.

The children in the SurfaceBot group sometimes changed sitting position but by doing so they came closer to the storyteller and the SurfaceBot. The children in the group without the SurfaceBot were more distracted by other things, like the camera were they could make funny faces to, see figure 21, or their own glitter shirt. This can also happen because boys are generally a bit more restless than girls and in the groups with no SurfaceBot there were more boys.

5.4 Discussion

The result of this research is that the SurfaceBot does have a positive influence on recall in children. But there were some limitations and flaws in the experiment. For starters there may have been a gender effect but this is not possible to check because in the questionnaire there was not asked about the gender of the children. The questionnaire also was short, about some effects there was only one question. This was a conscious choice because the questionnaire also should not have been too long. But the questions could have been more equally spread. It's possible that some questions were harder to understand and since the questions were read aloud it is good possible that in one group one question was more clear than in a other group. Some questions from the questionnaire may have been too easy while other may have been too hard. There were questions that 77% did answered correctly and questions that 31% answered correctly.

5. Conclusion

This chapter provides the answers to the research questions asked in the first chapter. First the sub questions will be answered to give a good overview of the complete project. Secondly, the main research question will be answered. Thirdly other observations that are made that are not closely related to the research question but are still interesting will be mentioned. After that the answers of the questions are discussed, why the answers are what they are and what could cause this. Lastly, optional further development of the project will be stated.

6.1. Research questions

The main research question that were asked in the introduction are:

How can a SurfaceBot be used during a storytelling activity to make children have better recall of the story?

What is the effect on children's recall of events in a story if a SurfaceBot is used to emphasized events in a story?

The four sub questions that were asked are.

1. *What has already been done in the field of robots and storytelling and what are opportunities for research that have not been done yet?*
2. *How can storytelling and multimedia help children in learning?*
3. *How can the attention of children be kept during a storytelling activity?*
4. *How can tangible objects be used during a storytelling activity?*

The first research question was what has already been done in the field of storytelling and multimedia systems. Most of the systems that are focused on storytelling with children are focussed on having the child make a story and in this way stimulate creativity and language development in that child. The research that was found was mostly about multimedia systems and less about actual robots. One research that was focused on robots tested if a Human Robot Collaboration (HRC) was more preferable or a Robot Only (RO) method during a storytelling activity. The conclusion from that was that HRC is preferred. So it was preferred to have a story told with both a human and a robot instead of only having a robot telling the story. This is why a HRC method is also used in this research. A lot of the systems were presented as stuffed animals, or other cute figures. The use of facial expression and human attributes like moving hands, having eye contact and showing a personality helps people feel connected by the robot. The second part of the first research question was what has not been done already. As stated before a lot of the already existing systems are more a multimedia system than a robot. And are more focussed on creativity and language development and not so much on recall and memory. This means that there is an opportunity to use storytelling and the support of a robot to stimulate better recall in children.

The second research question was about how storytelling and images can help memory and learning. Storytelling can help learning because by presenting facts inside of a story it is easier to connect those facts to other events in the story and to personal experience. This makes that the fact is not a separate chunk of information but it is connected to other information. Multimedia can also help in learning. Mayer's cognitive multimedia learning theory states that people have two processing channels: a verbal and a visual channel. When those are both stimulated at the same time the information is in the working memory at the same moment. The brain will connect the two pieces of information and is able to link it to other information. This

makes it easier to remember and to recall. In this research the movement, the landscape images, and the facial expressions are stimuli of the visual channel while the story that is told is a stimuli of the verbal channel.

The third research was about how to get and keep attention of children during a storytelling activity. There are a few things that help with this. Mainly, be clear to the children. At the beginning of an activity state a clear learning goal for the children. This way children can work towards it. Be precise to them and be enthusiastic. When a storyteller is enthusiastic to children, the children will become enthusiastic and curious as well.

The fourth research question was about how a tangible object can be used during a storytelling activity. For this research question a interview was held with a storytelling volunteer that tells stories to children and uses tangible objects during his storytelling activities. He uses puppets and small objects that are mentioned in the story. He said it was best used when it is relevant and out of view of the children when it is not. He mentioned that using a robot could be beneficial for keeping attention to the story and if the attention wanders also being able to get it back.

The first main research was about how a SurfaceBot can be used during a storytelling activity to make children have better recall of the story. This is discussed in the chapter 4, design. The decision of the results are the story, the locations and the actions of the SurfaceBot. The story that is used is Nungu and the elephant which is an adaption of the book Nungu and the Hippopotamus by Babette Cole [33] and can be found in Appendix A. In the story there are four locations where the main character goes to. These four locations are four separate images on the ground, the looks of them can be seen in figure 12, 13,16 and 17. The actions of the SurfaceBot are facial expressions, movement and sounds. A list of all these actions can be found in Appendix E. Facial expression are chosen so the SurfaceBot simulates human characteristics which makes people feel more connected. Movement is chosen because it is a clear visual to the traveling in the story. Sound is chosen because if a child is not paying attention and is looking somewhere else, sound is a way to get attention back to the SurfaceBot. This is very clear in the video analysis.

Lastly the main research question was about whether a SurfaceBot has influence on recall during a storytelling activity with children. The conclusion can be made that the SurfaceBot makes a difference in the recall of children. An experiment was conducted where a student told a story to six, seven, and eight years old from grade three and four of OBS de Regenboog in Enschede. The children were separated in four different groups with an in between groups experiment. One group had children from grade three with support of the SurfaceBot, one group had children with grade three without support of the SurfaceBot, one group had children of grade four with support of the SurfaceBot, and one group had children of grade four without the support of the SurfaceBot. Afterwards the children filled in a questionnaire with questions about the story. First all the different functionalities of the SurfaceBot were analysed. Here there was not a lot of significant difference. To test the overall influence of the SurfaceBot instead of the separated functionalities the total results were compared. Here there was a significant difference that the SurfaceBot has a positive effect on recall of the children if both grades were combined and regardless whether the events were supported by the SurfaceBot or not.

6.2. Discussion

The results of the experiment were that the SurfaceBot had a positive effect on the recall of the children. This could be an false positive because it could have been influenced by different aspects. First of all the small number of participants. This number could lead to coincidental differences. Other things that could have influenced the results are the boy girl ratio of the groups. In the groups that had no support of the

SurfaceBot there were more boys than the groups that had support. This may have influenced the level of attention in the children. That the SurfaceBot had a positive effect could also mean that tangible objects have a positive effect on recall of children. If a puppet would have been used the same positive effect would be visible or even more because it would be less distracted. The SurfaceBot could was never out of view but was present at the location where the main character also was. With smaller tangible objects it would be possible to have them out of view.

For the children in grade three it was the first time seeing the SurfaceBot, this was not the case for the children in grade four. In grade three there was a significant difference between the groups with the SurfaceBot and the groups without. In grade four this difference was not significant. This means that the group that did not saw the SurfaceBot before had a bigger effect than the group that was already a bit familiar. This may mean that the effect was a novelty effect. The children only paid attention because it was new and they had not seen it before.

The questionnaire could also had an influence. Both in the way it was asked to the children and in the way the questions were analysed. After the activity the questionnaire was read aloud to the children and repeated until every child filled in the question. So some questions were maybe repeated more with one group compared to the other group, this can have made it more clear and easier to answer a particular question. The questions of the questionnaire were not equally spread, there was one question about emotion and three on sound. This should have been spread better. With only one questions it may have been the way the question was asked why some answered it correctly or not.

The design was only tested on a couple of students and only small design choices, not the entire activity. After testing the separate design choices were made a entire user test should have been done to see how students reacted. After testing the activity on students the activity should have been tested on children of the age six till eight. This to test if the activity is understandable for them.

The controls of the SurfaceBot were done manually, the timing during the activity went okay but humans are never perfect. So probably the timing was in all the groups slightly different. The same goes for the storyteller. This should always be done by a human to get the desired effect, but humans never reproduce the exact same performance. This may have had effect on conveying the story to the children.

The State of the Art is about how storytelling and multimedia can help children with learning. The final design of the activity has nothing to do with learning. It is a fun story with different events that the children should remember. If the story was about a subject from the curriculum of the children they may have reacted different. Maybe they would remember the facts of the story better or maybe less.

The SurfaceBot has a friendly appearance but the face is representing a human face. It could be confusing because the SurfaceBot also showed emotions the elephant in the story was feeling. This could have been prevented by adding a second SurfaceBot. This may would have lead to more confusing since there is more to see that is not always relevant. When this would be implemented a way to not show both the SurfaceBot should also be implemented. This way the children will only focus on the SurfaceBot that is relevant at that moment and not look at the other one.

The storyteller from the Wilhemina Children's Hospital told in the interview that tangible objects that stay in view when not relevant anymore can distract more than do good. In this experiment there was chosen to keep the SurfaceBot in view of the children. This because otherwise the SurfaceBot should be driven out of view or hidden behind a curtain what probably would have been more distracting.

The story is targeted children around the age of seven. So this is a suitable group for the story. The interests in children differs. So some children may be more interested in the story than others. This is

something that could only be avoided by reading more different themed stories. In this thesis the class did not have time for that.

Overall there are a lot of things that could have influenced the results. This means that although the results was significant relevant at $p = 0.1$. It needs to be tested with a bigger sample size. Since the results would not have been significant relevant at $p = 0.05$ which is also a common measure.

6.3. Further work

In addition to the discussion it would be interesting to see if there is a beneficial effect in using the SurfaceBot during a storytelling activity compared to the use of a puppet or other tangible objects. This could be done with the same functionalities or the functionalities could be changed. The functionalities could be changed that one SurfaceBot represents one character and the image shown on the tablet represents that character. For example, for the elephant the face of an elephant could be used instead of a human face. In this scenario it would be good to still have the SurfaceBot representing human emotion the same way animals in stories often have human characteristics. This makes the audience feel connection to the character and the SurfaceBot. This should be tested if two SurfaceBot make things more clear or only provide more confusing.

The controls of the SurfaceBot should be made more accessible. The controls are really basic but when following a set path the precision is not perfect and the timing is also not automatically correct. The Zumo robot could follow a set path and make sure the SurfaceBot is always facing the front so the facial expressions are visible. The SurfaceBot could also be programmed that one button press makes the SurfaceBot do the next action. This way the SurfaceBot could still follow the story, if the storyteller goes a bit slower the SurfaceBot doesn't do the next action already but the timing is also a bit easier to carry out.

For further tests with the current functionalities and focus there should be more respondents, a better gender ratio, and more focus on the difference of the language spoken at home. The focus of the experiment could also change a bit to test it with people of different ages and if using it to educate works also. This could be done by incorporating content from the curriculum inside the story and see if children do better on tests. The design of the questionnaire should be different. There could be more questions and the spread of the questions should be equally spread.

The focus could also be changed toward long term effect. So, telling a story and some weeks later there is a test if children recall the story better when in the SurfaceBot group. The current test was a lot on short term, when the story ended the questionnaire started with no time in between.

For future use there should be made some guidelines for teachers. A learning program for classrooms. The design of the SurfaceBot is that is affordable for most schools. The class the experiment was carried out in already had tablets. The base of the robot is 3D printed and the wheels are also affordable. To make use of this there should be clear guidelines and easier controls. This so teachers can make and/or use their own stories that are related to the curriculum the children need to learn.

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Appendix A – Story

Nungu en de olifant

Lang geleden ver weg in Afrika was er een olifant die woonde bij een meer in het oerwoud. De olifant plaagde de mensen in het dorp. Hij sloop niet alleen 's nachts het dorp binnen om alle mais uit onze tuinen op te eten. Wat erger was, dat hij aan de kant van het meer achter de bomen en struiken wachtte tot de kano's van de mensen uit het dorp langs kwamen. Dan kwam hij tevoorschijn en plonsde zó hard het water in, dat alle kano's omsloegen door de golven. Hij lachte dan zó hard dat de hutten in het dorp ervan schudde en sommige zelfs in elkaar zakten…

De mensen vonden dat helemaal niet leuk en werden er zelfs een beetje verdrietig van. Krijgers probeerde hem daarom te verjagen. Maar toen hij de krijgers aan zag komen werd hij zó kwaad dat hij water uit het meer op dronk, Alles verdween zomaar in een aantal slokken de maag van de olifant in. @@

De krijgers die achter de olifant aan ging bleven in de modder steken! De olifant liep het oerwoud in… En daar was het meer verdwenen… weg met de olifant diep het bos in…

De opa van het jongetje Nungu had dit aan hem vertelt. En opa zei met een toon van verdriet: 'Nungu, toen ik zo oud was als jij zwom ik vaak in het meer en ging ik vissen en varen in mijn kano. Maar nu is er geen water meer…'

'Maar hoe kunnen we dan het water terugkrijgen, Opa?', vroeg Nungu.

Opa wees naar een leren zakje, dat aan een boom hing. 'Daarin zitten een heleboel medicijnen die ik van mijn opa heb gekregen. Er is een bijzonder medicijn bij waardoor de olifant zo de hik zou krijgen, dat al het water uit zijn bek zou komen. Dan zouden wij onze rivier weer terug hebben!

Die nacht werd Nungu wakker.

'Als ik de olifant zou kunnen vinden en ons meer terug zou krijgen, dan zou mijn moeder niet zo ver hoeven lopen om water te halen. Ik zou kunnen zwemmen, vissen en kanovaren, net zoals opa dat vroeger deed.'

Nungu stapte zijn bed uit, bond wat te eten en een leren zak met water op de rug van zijn ezel en ze vertrokken. Nungu en de ezel liepen, de hele ochtend, de hele middag, tot het donker werd. De ezel en Nungu gingen onder een boom liggen en vielen in slaap.

Toen Nungu wakker werd, was het donker. In de verte hoorde hij leeuwen brullen en andere nachtelijke geluiden en in het maanlicht zag hij vleermuizen vliegen. @@

Door al die nachtelijke geluiden werd hij toch een beetje bang, te bang om weer te gaan slapen dus maakte hij zijn ezel wakker en samen liepen zij verder, in het maanlicht.

Vlak voordat de zon opkwam stond de ezel stil en begon te snuiven. Hij rook water! Hij draafde weg naar een muur van dik riet. Daarachter, tussen de groene bladeren, zag Nungu een kleine rivier. Zebra's, giraffen en neushoorns stonden daar rustig te drinken en graasden langs de oever.

En daar… daar stond een reusachtige olifant! Langzaam liep hij naar de bomen en terwijl hij dat deed, klonk er een luid geklots uit zijn buik. Nungu wist dat hij dé olifant gevonden had!

'Goedemorgen, meneer Olifant', zei Nungu dapper.

'Ook Goedemorgen', antwoorde de olifant.

'Heeft u goed slapen meneer Olifant?'

'Oh nee', zuchtte de olifant. 'Ik heb me nooit meer helemaal goed gevoeld sinds ik een rivier heb leeggedronken, toen ik een keer een beetje boos werd. Hoe vaak ik ook naar de wc ga, het water komt er niet uit. Het klotst maar in mijn buik. Heel vervelend' zei de olifant vol verdriet.

'Als u met mij meegaat', zei Nungu, 'zal mijn opa u een tovermedicijn geven, waardoor u zo erg de hik krijgt dat de rivier uit uw bek stroomt.

'Mmm, goed, dan gaan we naar je opa', zei de olifant. En daar gingen ze… op weg naar het dorp.

Ze hadden pas een klein stukje gelopen toen meneer Olifant ging zitten.

'Oh, mijn buik!', kreunde hij. 'Ik kan geen stap meer lopen met al dat klotsende water erin.

'Nog een klein stukje', zei Nungu dan. En zo gingen ze verder…

Het duurde lang, maar ze kwamen bij het dorp. Opa zag Nungu en de olifant aankomen. Hij pakte snel het zakje en ging naar ze toe. 'Hier is het tovermedicijn', zei opa en hij hield een flesje omhoog. Meneer olifant opende zijn grote bek en slokte alles op, met het flesje erbij! @@

Toen liet hij zichzelf in de droge bedding van het meer zakken en … begon te hikken. @@

Meneer olifant hikte zó erg dat het water uit zijn bek stroomde en de droge rivierbedding vulde.

'Oh, ik voel me stukken beter', zei hij lachend.

Toen de mensen uit het dorp het water zagen, waren ze dolblij! Ze dansten en ze zongen.

Met een tevreden zucht liep de olifant weg.

Zo kreeg Nungu en zijn dorp het meer terug;

Nungu kreeg van opa een heel mooie kano en kon nu heerlijk varen, vissen en zwemmen in het meer. Hier was hij heel erg blij mee.

En daarom leggen de mensen uit het dorp nog steeds 's avonds 5 grote maiskolven aan de oever van het meer voor de olifant, om hem te bedanken het water weer terug te geven. En de olifant… die laat geen kano's meer omslaan, hoe leuk hij het ook vind…

Vragen

Over mij:

1. Mijn leeftijd is: ………………………………………………………………

2. Ik zit in groep:
   o 3
   o 4

3. Thuis spreek ik:
   o Nederlands
   o Een andere taal namelijk …………………...

Over het verhaal:

1. De hoofdpersonen van het verhaal zijn een olifant en een:
   o Ezel
   o Meisje genaamd Naria
   o Jongetje genaamd Nungu
   o Tijger

2. Toen het meer werd leeg gedronken voelde de dorpsbewoners zich:
   o Verdrietig
   o Blij
   o Boos
   o Angstig

3. De olifant hield het meer in zijn buik ondanks dat hij steeds:
   o De hik had
   o Een boer moest laten
   o Heel vaak naar de wc was geweest

4. Waarom wil de hoofdpersoon het meer uit de olifant hebben:
   o Om te kunnen genieten van het meer, water te halen en er in kunnen varen en vissen
   o Om te olifant te helpen
   o Hij had een middagje niks te doen

5. Waarom was de hoofdpersoon bang en wilde hij niet meer slapen?
   o Door de nachtelijke geluiden
   o Voetstappen
   o Gesnuif van een dier

6. Het tovermedicijn van opa zorgde dat de olifant:
   o Heel erg moest plassen en het hele meer uit plaste
   o Werd lek geprikt en het meer zo uit z'n buik liep
   o Heel hard moest hikken en zo het meer uitspuugde

7. Het tovermedicijn was:
- o Een pilletje dat de olifant moest slikken
- o Een drankje dat de olifant moest drinken
- o Een spuitje dat in z'n buik geprikt moest worden

8. Waar vond de hoofdpersoon de olifant?
- o In het bos
- o Bij de rivier
- o Bij het meer
- o Naast het dorp

9. In welke volgorde gaan ze langs de volgende plaatjes:

A. Rivier

B. Bos

C. Meer

D. Dorp

Schrijf ze op in goede volgorde, locaties mogen 2 keer gebruikt worden.
Voorbeeld: A. Rivier, B. Bos, D. Dorp, C. Meer, B. Bos
1. …
2. …
3. …
4. …
5. …

Heel erg dankjewel voor het invullen en het mee doen met de activiteit!!!

Appendix C – Consent form

Betreft: Toestemming voor deelname aan activiteiten op RKBS De Regenboog in het kader van het onderzoek naar *'leren met robots'* van de Universiteit Twente

Geachte ouder/verzorger,

21 juni 2018 werkt groep 3/4 van RKBS De Regenboog samen met de Universiteit Twente in het kader van een onderzoek naar leren in de klas met robots. Hiervoor komt 21 juni tussen half 9 en 12 iemand in de klas. Daarbij maken de kinderen kennis met een robotje en helpen ze als gebruikers hiervan de universiteit met onderzoek en met het verder ontwikkelen van de technologie.

Voor deelname aan deze activiteit is uw toestemming vereist. De informatiefolder biedt hierover meer informatie.

Als u akkoord gaat dat uw kind/kinderen hieraan mee doen, wilt u dan hieronder de opties aankruisen waarvoor u toestemming geeft, de informatie invullen, ondertekenen, en aan de leerkracht van uw kind geven?

☐ **Ik ben over dit onderzoek volledig geïnformeerd en geef toestemming dat mijn kind/kinderen hieraan mag/mogen deelnemen. Ik geef toestemming voor het verzamelen van geanonimiseerde onderzoeksmaterialen zoals beschreven in de bijbehorende informatiefolder. Ik geef ook toestemming voor het maken van video-opnames voor onderzoek en evaluatie. De video's worden enkel door betrokken onderzoekers bekeken en zullen nooit publiek worden gemaakt of vertoond aan derden voor demonstratie of rapportage.**

☐ **In aanvulling op het bovenstaande geef ik toestemming om beelden uit de video opnames te tonen in de openbare presentatie en het verslag van het onderzoek dat online gepubliceerd zal worden**

Naam kind……………………………………………………………………………………

(Eventuele 2ᵉ kind)………………………………………………………………………

(Eventuele 3ᵉ kind)………………………………………………………………………

Datum………………………………………………………………………………………

Ouder/verzorger…………………………………………………………………………

Handtekening:

……………………………………………………………………………………………….

Contact informatie

Mocht u vragen hebben over dit onderzoek dan kunt u contact opnemen met Rosa Amptmeijer (r.s.amptmeijer@student.utwente.nl) of Mariët Theune (m.theune@utwente.nl) Voor meer informatie: zie de informatiefolder bij dit formulier**.**

V1.5 – Juni 2018

Appendix D – Information Brochure parents

<table>
<tr><td>Technologie voor het nieuwe leren van de toekomst</td></tr>
</table>

Bij de Universiteit Twente doen we onderzoek naar hoe robots het onderwijs kunnen verbeteren.

Voor dit onderzoek organiseren we <u>activiteiten op scholen</u> waarbij o.a. gebruik wordt gemaakt van robots. Voor ons, de onderzoekers van de Universiteit Twente, levert dit waardevolle inzichten op waarmee de technologie verder ontwikkeld kan worden. Het onderzoek richt zich dus niet op uw kind maar vooral op verbeteren van de technologie.

In deze folder leggen we uit wat dit voor ouders en kinderen betekent, hoe uw kind mee kan doen aan deze activiteit, en welke basis-spelregels we in de samenwerking hanteren. U beslist zelf of uw kind mee zal doen aan deze activiteiten.

Lees de folder rustig door voordat u beslist of uw kind mee mag doen. Als u meer wilt weten kunt u contact opnemen met Rosa Amptmeijer (r.s.amptmeijer@student.utwente.nl), de uitvoerende student of Mariët Theune (m.theune@utwente.nl), de eindverantwoordelijke onderzoeker.

Onderzoeksactiviteiten van Universiteit Twente op RKBS De Regenboog: Hoe werkt het?

Wat gebeurt er tijdens de activiteit?
De kinderen krijgen een verhaal te horen. Naast de verteller van dit verhaal rijdt er een robotje rond dat naspeelt wat er in het verhaal gebeurt. Daarna word via een aantal vragen over het verhalen gekeken of het robotje zorgt dat kinderen informatie beter onthouden. Tijdens het onderzoek is er ook een controlegroep die alleen het verhaal te horen krijgen zonder de robot. Om deze kinderen niet teleur te stellen zal de activiteit achteraf ook in de klas gedaan worden zodat ze alsnog de robot kunnen zien. Natuurlijk mogen ze dan zelf ook nog vragen stellen.

Welke gegevens worden er verzameld?
Gedurende de activiteit worden de kinderen geobserveerd en worden er video-opnames gemaakt. Ook is er achteraf een korte vragenlijst over de activiteit die ze zojuist hebben afgerond. De video's en interviews worden zo anoniem mogelijk verwerkt en bewaard. De videobeelden worden na het afronden van het onderzoek direct verwijderd.

*Is het verplicht om mee te doen?*
Uw kind doet niet mee zonder toestemming van u als ouder of wettelijk vertegenwoordiger. U beslist zelf over deelname van uw kind aan het onderzoek. Als u besluit niet mee te doen, hoeft u verder niets te doen. U hoeft niets te tekenen. U hoeft ook niet te zeggen waarom u niet wil dat uw kind meedoet.

Wat als mijn kind tijdens een sessie niet meer wil?
De onderzoekers zijn alert op signalen dat een kind echt niet wil. Zo nodig wordt de sessie afgebroken. De leerkracht heeft veel ervaring met de kinderen en kan ook als dat nodig is tegen de onderzoekers zeggen dat een sessie met een kind niet doorgaat. Als het kind zelf tijdens de activiteit niet meer wil kan het op elk moment weggaan.

Wie kan de beelden en interviews bekijken?
De video-opnames zijn enkel toegankelijk voor mensen die betrokken zijn bij dit onderzoek. Beelden uit de opnames kunnen, als u daarvoor toestemming geeft, gebruikt worden in de verslaglegging of tijdens een openbare presentatie. Het zal gaan om alleen dingen duidelijk te maken en niet voor promotiedoeleinden.
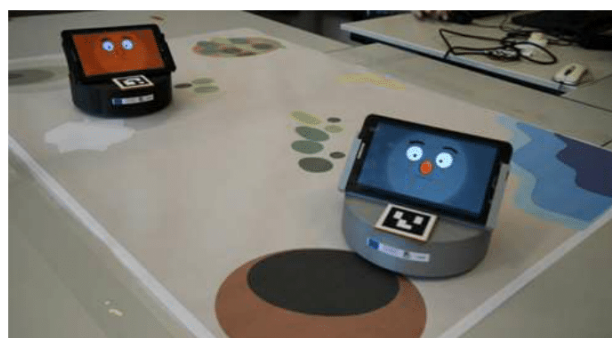
De robot die gebruikt zal worden met het onderzoek

Krijgen de ouders ook informatie over de resultaten?
De universiteit zal onderzoeksresultaten delen met de school. Daarnaast is het ook mogelijk contact op te nemen met de student en te vragen om de resultaten. Deze zullen we u dan toesturen.

Meer informatie en onafhankelijk advies.
Wilt u graag een onafhankelijk advies over meedoen aan dit onderzoek, of een klacht indienen? Dan kunt u terecht bij Anja Strootman-Baas, de secretaris van de Ethische Commissie (ethics-comm-ewi@utwente.nl). De commissie bestaat uit onafhankelijke deskundigen van de universiteit en is beschikbaar voor vragen en klachten rondom het onderzoek.
Voor overige vragen kunt u terecht bij de leerkracht of bij de onderzoekers van de universiteit.

Appendix E – Table with all actions

Line number	Actions	Category	What happened in the story	Question about this?
9	Show a sad face	Facial expression	The villagers were sad because the elephant bullied them	Question 2
12	Play swallowing sound	Sound	The elephant drank the entire lake	
16	Show a sad face	Facial expression	Grandpa is sad because there is no more water in the lake	
26-28	Move towards forest	Movement	Nungu goes towards the forest to search for the elephant	
30	Play jungle night sounds	Sound	Nungu wakes up scared and hear the night sounds around him	Question 5
31	Show a fear face	Facial expression	Nungu is afraid of the nightly sounds	
32-34	Move towards river	Movement	Nungu continues walking towards a river	Question 8
43	Show a sad face	Facial expression	The Elephant is sad that he did not sleep very well	
46-48	Move halfway towards village	Movement	The elephant and Nungu go toward the village, the elephant is tired and stops halfway	
49-50	Move the rest towards village	Movement	They continue walking	
52	Play swallowing sound	Sound	The elephant swallows the medicine for the hiccups	Question 7
52	Move to lake	Movement	The elephant moves towards the lake	
53	Play hiccups sound	Sound	The elephants starts to hiccup and spit out the entire lake	Question 6
55 -60	Show happy face	Facial expression	The elephant and the villagers are happy that the lake is back where it belonged.	

Appendix F – Persona and Scenario

Persona

Lisa

Name: Lisa
Gender: Female
Age: 27
Occupation: Middle school teacher
Family situation: Married with one child and a cat.

Description:

Lisa is a school teacher, ever since she was little this was her dream job. Besides teaching she loves to go for a Sunday morning run, sit on the couch and watch TV and on the weekends go have drinks with her friends. She teaches grade four and loves to tell the children stories. Her favourite moment in the week is Monday morning when all the children are in a circle and tell what they did in the weekend. She would love to incorporate more stories into her teaching.

Maria

Name: Maria
Gender: Male
Age: 45
Occupation: Middle school teacher
Family situation: Divorced with three children and two dogs.

Description:

Maria is a school teacher, she has been for 20 years already and she still loves every day. With children every moment is different and that is what she loves most about the job. She is a teacher for grade 7. Her favourite subject to teach is history. With history she is free to tell all about romans, knights and castles. When telling a story about an ancient time she is very enthusiastic and because of this a lot of children in her grade also love history.

The pictures used for the Personas are Grace Helbig and Cukaj Katrina, the photos are from the following site:
https://twitter.com/gracehelbig
http://edition.cnn.com/CNN/anchors_reporters/cukaj.katrina.html

Scenario:

Maria uses storytelling already in her teaching. When teaching history she teaches is by telling educational stories about the era she is teaching. She notices that children like this way of learning. With the help of the SurfaceBot she can make more things clear in her story. When talking about an artefact she is able to show it on the screen of the SurfaceBot. While it is driving around in a town build by wooden blocks. By seeing this while hearing the information the children are able to visualize it remember the story better.

Reflection report

Rosa Amptmeijer

S1594737

Graduation semester 2017-2018

Introduction

The graduation project researches if a robot can help children recall a story that is told to them. The robot used for this is called a SurfaceBot, it is developed by the CoBotNity project from the HMI research group at the university of Twente[1]. The aim of the project is to test if this can be used with stories so that later on it can be used with teaching. It is a tool to make teaching more fun with technology and storytelling.

This is the focus of the project because both storytelling and adding multimedia to a storytelling activity are beneficial for the learning of children. The focus on storytelling is because when facts are presented inside a story people are able to connect them to other events inside that story and to experiences in their own lives. With this connection it's easier to remember matter [2]. The adding of multimedia to a storytelling activity achieves the same goals. Mayer states in his cognitive theory of multimedia learning that every person has two processing channels. A verbal and a visual channel, if both are stimulation at the same time. If there both procession channels are stimulation at the same time, the information is first stored in the working memory part of the brain. The brain will connects the visuals and the verbal parts to each other which makes it easier to remember[3].

For a reflection on the graduation project there will be looked at the ethical and philosophical issues that are raised. Firstly there will be looked at general issues raised by robots, secondly there will be look at issues the system raises and later there is looked into the experiment.

Robots

The SurfaceBot as used in this project can be seen as a robot. As the SurfaceBot is used in this project there is no artificial intelligence involved. With the original setup of the SurfaceBot is used it is. It is follow a line when moving but when two SurfaceBot are on the board they will not bump into each other. It is recognized that when followed a line and the other SurfaceBot is in the way of that line the SurfaceBot will not move any further till the other SurfaceBot is moved out of the way. This is not a advanced form of intelligence and this SurfaceBot will not soon be able to raise the general concerns a robot raises. It is still relevant to see what these issues are because when the functionality of the SurfaceBot will be further developed it may be able to do more by itself. For example move according to what you say to the robot and react on the reactions of the listeners of the story.

A general concern there is on robots is that they will take over certain jobs. This concern has been around for decades. First this concern was with the automation of industries and later with internet ventures. The response to this is that robots will mainly replace jobs with the three D's, dull, dirty and, dangerous, and when replace humans are able to focus on other fields that have more impacts. [4]

When replacing jobs with the three D's there should not be a lot of problems on a great scale. Only personal problems of people that lose their job and their income. But robots are also better at more complicated tasks. For example doing delicate surgery requisite a steady hand, which not all humans are able to do, and a lot of knowledge. A robot could be programmed to stay steady and instructed to perform the task. There probably will be less complications but over time the knowledge on how a surgery is performed would be forgotten. This is a more pressing concern for a lot of people because this means that there will be a bigger dependent on robots. Which leads the society more fragile for cyber failures and attacks. [4]

Besides the mentioned concerns about knowledge and jobs there are more concerns that are more relevant to the SurfaceBot. There have been cases where soldiers were sobbing when a bomb-disposing PackBot met its end because the robot has saved their lives [5]. Robots are caring more and more for children and elders but there are not a lot of studies done on the effect of having robot contact instead of human contact [4]. Some people even claim that robots will soon become our lovers, they are not able to cheat and will always listen [6]. This means that robot are not able to take over jobs but also emotional support and company to more lonely people. Since there are no results on long term effects of this it is still too early to say anything about that. And maybe there will be some positive effect to this.

Bill Gates observed that the evolution of robots is almost equal to the evolution of the computer. As a pioneer of the computer industry he has closely observed the evolving of that industry [7]. When we were at the beginning of that industry no one could have predicted it to have such a strong impact on our way of living. But also a lot of dangers were not seen beforehand. For example addiction people would have to the internet, game or, pornography. So there are probably also still a lot of dangers in the evolvement of robots that are not seen yet [3]. So although it is certain that robot will be able to take over jobs it is uncertain to what extend this will happen and if there will be a society that is on a knowledge base dependent on robots. Where people that feel lonely will have a robot companion to be less lonely and if this will succeed.

SurfaceBot

Human interaction

The importance of Human touch and interactions is show in multiple studies. Humans are social animals and we find more strength in being together than being an individual. Loneliness increases the risk of early death by 50%, which is even higher than the risk obesity forms [8]. Although it is not yet researched if people feel less lonely with a robot companion it probably still feels a lot different than real human contact. Besides loneliness as a health issues, human touch can work stress relieved, reduces social anxiety and makes people feel happier[9]. Touch can also be used to communicate empathy with results in relieving the feeling of pain [10]. A hug from a friend can produces feelgood hormones which help boost the immune system and communicated emotions to each other[9].

Research shows that touching and interacting with another human being is good as so many levels that there should be done anything to promote this. With the arrival of smartphone and more technology in general it is endangered. People look at there smartphone more than talking together over a cup of coffee. Over time this means that more people are at risk to develop health issues.

Storytelling is a way for a lot of families to tell their children about their life. And between friends people tell stories to get know each other better. The activity where this system is most involved is telling a fairy-tale or any other fantasy story to children. This activity is most used between children and parents and children and teachers. Where this activity is a fun way to learn morals and spend time together. With a parent-child relation maybe even while lying next to each other. With this system there will be less intimacy between the storyteller and the listener. This because both of them will be more focused on the SurfaceBot than on each other. This contributes that a very positive part of storytelling is neglected and there is less contact. The other side of the story is that this system is promoting storytelling and without the system the activity may not even take place at all. Storytelling is beneficial for a lot of other things included language development, creative and critical thinking, and memory [11][12]. So the promoting of this activity is also important.

Creativity

The development of creativity in children is important because creativity is the base of critical thinking and problem solving. Creativity involves adaptability and flexibility in thoughts [13]. It helps children to prepare for life in the way they think [14]. Creativity and creative thinking can be stimulated in a lot of difference ways. Promoting pretend play in children, pretend play is form of playing where children pretend to be something different. This can be seen as a form of storytelling because children make up their own stories in their minds and perform them [15]. Storytelling is a way creativity can be sparkled in children. By telling children a story they imagine a world wherein that story exists. Characters get a face and blanks are filled in. They can draw characters that are spoken off in a story or caracters are used in free play a few weeks later [16]. So storytelling is a way to stimulate creative thinking and creativeness in children.

The SurfaceBot will act out parts of the story, show movements, show images, and play sounds. Which may lead to children having less opportunity to create their own worlds since more is already played out for them. The same goes with picture book "If a picture book both shows and tells us everything, it leaves very little work for the reader to do and, though the story may be pleasing, it seldom goes on living in our minds"[17]. This suggest that although the SurfaceBot makes children recall the story better. There are other parts of the brain that are less stimulated. But unlike picture books not everything is displayed so not all the blanks are filled in by the SurfaceBot and there are still some options left for imagination.

Besides storytelling there has been similar systems of the SurfaceBot that were designed to stimulate creativity focused on storytelling. For example a tabletop that made use of artificial intelligence where children could tell a story on top of it. Children would cooperate with each other and the tabletop gave suggestion[18]. Or a system called GENTORO, it consists of a mobile robot and a handheld projector. The story is first made in a editing module and then expressed by the robot. The projector could be moved around the room[19]. This made children more enthusiastic by making different ies and trying new things out. So similar systems contributes to the creativity of children, probably this system is not be a bad influence on creativity.

Conclusion

The main issue that the system raises is the less human nature of contact to human contact. This contact can be really beneficial for a lot of different reasons. From stress relief to feeling less lonely and live a longer healthier life. The effect of human to human contact is already proven but there has not been done a lot of research on how a robot influences this contact and how much it is a negative effect. The positive effect may be less but there may not be a negative effect. Besides there being not a lot of research it is not possible to say how much effect the SurfaceBot will have on the parent child relation. The same goes for the effect on creativity. Promoting creativity development in children is already proven to be important but the effect of robots and in particular the SurfaceBot is really unclear. A storytelling activity in general has a positive effect on creativity by children. A picture book stimulates theif fantasy less than a book without pictures because there is more space for imagining your own world.

The experiment

Design of the experiment

The experiment took place in a classroom with a combined grade of 3 and 4 from RKBS de Regenboog in Enschede. The children that participated were aged six, seven, or eight. The experiment started with a small introduction to what was going to happen, than the activity started. The participants listened to a story told by a storyteller, while the SurfaceBot emphasized events by showing different facial expression, making sounds and, by moving around when in the story main characters were walking around. To evaluate the results a questionnaire was given afterwards for a quantitive analysis and the children were videotaped for qualitative analysis. The test was focused on improving recall of the story by children. And no manipulation or deceiving was happening.

Consent

The test was done by children age six, seven and eight, this means that the consent was given by their guardians. Children may not have wanted to participated but felt like they needed because all of their friends went. It is also a possibility that if they felt unpleasant during the activity they would not have said so. The experiment was executed by two students the children have never met before This could have made them uncomfortable and/or made them more shy than usual. During the activity it was noted that when asked questions to the children, before, during or, after the activity the children backed away a little bit. So when the children would feel uncomfortable continuing the activity they would probably would not have said something because of the peer pressure and the unpleasantly felt towards the unknown students.

Privacy

During the activity the children were filmed with the consent of the parents. This footage is used to do qualitative research on. And the footage with blurred faces is used in the report and in the presentation. The data that is collected is on how well they recalled a story and for demographics only their age and the language they speak at home is gathered. These facts are not that important to keep for yourself like your pin code but since the research is only done in one class. With a combined grade and only 26 participants it is still really easy to backtrack the information and see which child said what about the activity. Same with the blurred footage, not all parents gave permission to have their child visible in a thesis and a presentation but with only 12 children from grade 3 it is still easy to recognize a blurry image of somebody from their clothes, colour hair and other characteristics.

Conclusion

The experiment is a standard research done where not much can go wrong but of course there are still things that should be taken into account. For example children and how they did not feel comfortable to say they want to stop with the experiment. Since there were not any unpleasant things done during the experiment and it was a fun activity it is unlikely that the children wanted to quit during the experiment.big. But if any of them did feel uncomfortable and wanted to quit, the students present would not have known this. The data that is gathered during the experiment is not very important personal data but since there were such a little amount of participants it would be probably be possible to trace the information back to the child that participated.

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