ROBIN - Designing a ROBot for Interactive Narratives to engage preschool children

Sveva Valguarnera
Università della Svizzera Italiana
Lugano, Switzerland
sveva.valguarnera@usi.ch

Monica Landoni
Università della Svizzera Italiana
Lugano, Switzerland
monica.landoni@usi.ch

ABSTRACT

Following a series of interviews with parents and teachers, and a cycle of collaborative design sessions with children aged 4-6 years old, this work in progress presents the design of an interactive storytelling robot able to engage preschool children in building narratives. Starting with a series of tools already on the market for this age range as a complement to reading aloud, we have elicited a number of requirements, using them to sketch a first version of ROBIN. We plan to further refine our work with another cycle of collaborative design sessions, and to implement a functional, high-interactivity prototype of ROBIN in the near future.

CCS CONCEPTS

• **Human-centered computing** → **User studies**.

KEYWORDS

robot, child-computer interaction, reading, preschool, children

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1 INTRODUCTION

Learning to read is one of the most important milestones in young children's lives, as it influences their learning outcomes in later life, with different pre-reading skills such as naming speed and phonological awareness being predictors of reading development in later years [18] [10].

Children's learning happens both in formal (school) and informal context (home and library); while the formal context is important and necessary, it is not enough for children to successfully learn how to read - especially as preschool education is not compulsory in many parts of the world.

Shared child-parent reading is an important bonding activity, part of a complex set of intimate practices at home [28]. In this regard, Vezzoli et al. report three points of tensions that can be used as opportunities for design: parents' busy schedules that cause them to have little time to organise and perform shared reading activities, the different level of engagement between parents and children, with the former preferring more complex and layered stories, and the negotiation regarding book choices. We build on the first of these three themes, while also considering the importance of dialogic reading [30] - a form of interactive reading in which children answer questions and reflect on the reading, that has shown to be effective in developing pre-reading skills [17] [21] [31] but that many parents do not know or cannot perform effectively.

Because of this real need, we focused our research on the design of tools to support the acquisition of pre-reading skills by young children, either alone, with peers or with an adult. In the spring of 2020 we conducted a series of contextual interviews with three parents and two preschool teachers (one of whom also had a child in preschool). We then proceeded, in the winter of 2021, with a cycle of six collaborative design sessions with 12 preschool children aged 4 to 6 years old, recruited through a local children's library. During the sessions, children were presented with several different kinds of existing tools for storytelling, both digital and traditional, and they were also involved in creative activities such as drawing. Basing our findings both in the interviews and the co-design sessions, we built on the children's preferences for tangible, interactive tools and came to the design of a humanoid, interactive storytelling robot that we named ROBIN.

2 RELATED WORK

The design of technology for storytelling, while relatively new, has proven useful to support literacy learning in young children in different ways. On one hand, some tools relies on tangible interfaces, and specifically on the manipulation of physical blocks, such as TOK [26], PageCraft [6], the t-books toolkit [25] and The Telling Board [22]. Storymat [8] and Kids in Fairytales [16] also involve the children's physical space, with the former capturing the movements children make with their stuffed animals on a colourful quilt, and the latter using Mixed Reality to motivate young children to engage in reading.

Other tools, on the other hand, focus on collaboration among peers, such as KidPad, Klump [5] and MyStoryMaker [20]. The use of physical artifacts is also present in Rosebud [12], that is however designed for older children. Some tools also allow for collaboration over a distance, such as The Conference of the Birds [7].

However, virtual peers can also be used to model narrative skills and practice literacy, such as Sam [23], that allows children to learn how to be critical listeners. Storydrawer [32] is also a tool designed to support children in creating stories through collaborative drawing.

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Robots have also been used to create interactive stories with children: a Wizard of Oz study showed that even young children are able to interact with robots by inserting new content in a story, relating it to the existing story [24], while storytelling with a listener robot as a side-participant, together with a reader robot, has proved to be more enjoyable than just reading with a reader robot [27]. As well as being enjoyable and engaging, storytelling with a robot can also have a positive effect on children's vocabulary: when playing a storytelling game, levelling a robot's language to a child's current abilities resulted in children using a more diverse language and creating longer stories [29]. Robots' social behaviour is also an important factor in their performance: for example, expressive robots narrating stories to preschool children have an effect on children's recollection of stories that is comparable to expressive humans, and better than static, inexpressive humans [9]. When used in an educational context, social robots have also been shown to have a positive effect on learning outcomes, even at a very young age [4]. Even when used in schools, social robots usually interact with children one-to-one, especially when they act as tutors. While our work, analogously to Belpaeme et al.'s [4] focuses on one-to-one interaction to support learning, we propose the use of a social robot in an informal, playful context.

However, children are not independent users of technology, and as such, parental expectations and concerns must also be taken in consideration: while an exploratory study suggest a generally positive attitude towards storytelling robots for children [19], the attitude of parents towards technology has a strong cultural component and can also change over time. Particularly, Swiss-Italian culture does not see the use of technology by children in a particularly favorable light; technology is rarely, if ever, used in schools and our interviews revealed that parents do not want their children to use screens much, especially after the Covid-19 pandemic forced them to rely on screens for both education and entertaining of their children.

Therefore, we propose to explore the design of a robot designed for and with children, for use in the informal context of the home, with the aim of assuaging parents' doubts and concerns about technology.

3 ELICITING REQUIREMENTS

3.1 Interviewing parents and teachers

In the spring of 2020, after the first Covid-19 lockdown which had led to widespread school closures and the adoption of distance learning even in preschools, we had to adapt our methodology to the new situation; while our original goal was to conduct a full contextual inquiry, observing children during shared reading activities in school before interviewing teachers, due to the pandemic we were unable to conduct field studies and so we conducted interviews with three parents and two teachers, one of whom was also parent to a child in preschool, both Swiss and Italian. While our interviews were geared towards getting a sense of how schools had handled the distance learning, and what could have been done better, we obtained several interesting insights on how the parents and teachers looked at the use of technology by young children, which have provided the foundation for the design of ROBIN. Specifically:

- The heavy involvement of parents in their children's educational activities, such as printing activity worksheets, sending them back and having their children watch videos, was hard for many parents, as they were working from home and had to juggle both family and work responsibilities.
- Teachers reported that many parents wanted to limit their children's screen time; one parent confirmed that, since children were already using media much more than usual, they would prefer screen-free educational activities for their children.
- The pandemic widened the already present digital divide: we interviewed very involved parents, who had time, devices and Internet connection for their children to use; that is, however, not the reality for many families - as the teachers confirmed. To become widespread, innovations should be affordable, and rely as little as possible on parents' time and effort or on Internet connections.

These insights led us to consider three main user requirements for ROBIN:

- **Screen-free**: we designed Robin to be a tangible, screen free robot, with which children can interact by either touch or voice.
- **Ease of use**: in our vision, children should be able to interact with ROBIN independently, but also with a peer or adult if available.
- **Usable offline**: Robin should not be dependent on an Internet connection; while a connection might be used to download updates or new stories, it should not be needed for everyday use.

3.2 Co-designing with children

Collaborative design with younger children is no longer a novelty, and it has in fact been around for 20 years [11], with many co-design techniques both adapted for use with younger children [15] [2] and specifically designed for them [13] [3]. Cultural probes and contextual interviews have also been used to capture shared parent-child reading experiences in their homes [28].

In the winter of 2021, we conducted 6 co-design sessions with 12 children aged 4 to 6 years old; each session lasted one hour, with usually two activities proposed per session. All sessions were recorded, with the consent of the children's parents. The children were recruited through a local children's library; therefore, they were already used to reading with their parents, and were already interested in books and storytelling. We opted for a small number of children over a longer period of time, to

Id	G.	Age
C1	F	4y 6m
C2	M	5y 8m
C3	M	4y 3m
C4	M	4y 8m
C5	M	6y
C6	F	3y 7m
C7	F	5y 4m
C8	F	4y 7m
C9	F	5y 11m
C10	F	4y 9m
C11	F	3y 6m
C12	F	5y 4m
C13	F	4y 9m
C14	F	5y 7m

Table 1: Id, gender and age of the children at the beginning of the study

allow us to build a rapport with the children and gain more insights into their thoughts.

Not all children participated to all the sessions, due to illness or other constraints. Children's age and gender are recorded in Table 2. During the sessions, children explored several tools for storytelling that are already present on the market, from traditional books, to paper game-books, to digital toys and eBooks.

During the first sessions, we conducted a direct observation of children's behaviour when involved in shared group activities with an adult. From the second sessions onward, we started each session by asking children what they remembered about the previous week's activities; after each session, we asked children which activity they had liked best, and why, and captured spontaneous comments and reflections in our field notes.

We also asked children to draw their ideas and wishes for a storytelling technology, following Barendregt's [2] results that showed how the Drawing Intervention method can be used to generate design ideas in younger children.

Finally, we analysed the recordings to find an objective metric of the children's engagement; we coded each activity by recording the length in minutes, the number of children involved, the type of activity (traditional or digital, interactive or not interactive and so on) and the number of activity-related utterances that the children spoke during the course of the activity.

Combining our observations with the analysis of the recordings and the drawings, we got several insights; some of them are in agreement with previously reported findings, such as the fact that tools and books that are explicitly designed for interaction between adult reader and children - such as gamebooks - elicit more interactions than traditional books. This finding relates to Hiniker et al.'s [14] study about play between preschoolers and parents, who reported that, in the absence of an explicit design for shared participation in a playful activity, the experience tends to be solitary. Other findings are, however, unique to this study:

1. Some game-books caused frustration in cases where there was only one "right" path, that led to the correct ending of the story. In this case, children had to go back to the start of the book, twice or sometimes more, before getting to the ending. They started expressing frustration and asking to see "new" pages, or commenting that they had seen a specific page before. This effect was more marked with older children, as expected. Therefore, we believe that game-books with multiple "happy" endings are to be preferred.

2. In bigger groups, shy or younger children tend to speak less, as more extroverted or older children interact more. However, we succeeded in engaging younger children by working in smaller groups (2-4 children).

3. When allowed to choose, children were drawn to tangible toys, even more than they were to a tablet. During free play activities, children spontaneously chose either tangible toys or books, while seldom reaching for the tablet.

4.They were especially drawn to Tellie, a humanoid robot that told stories and played music. Whenever possible, they took Tellie around, hugging it and touching its ears and limbs. When using Tellie, children reported that music was their favourite part of the experience.

5. While designed and marketed for children in that age range, many tools were not easy to use, and children were often confused on how to use them if they did not have any prior instructions, often asking for our help.

6. Many children were especially attracted to the stickers with emojis, stars or hearts that we used to allow them to express their preferences and thoughts. They even used them when drawing, and often asked to bring some home.

This led us to extract the following user requirements:

Interactivity: ROBIN should interact with children, asking them questions and reacting appropriately to their answers; however, ROBIN should support both voice and touch interaction as shy children are less likely to want to speak to a robot, or even an adult reader.

Attention keeping: ROBIN should support short stories, up to 10 minutes, offering frequent breaks with questions, sounds and light to keep the child's attention. After 10 minutes, the child should be offered a break and asked if they want to continue the activity.

Ease of use: Building on the "ease of use" requirement that we had elicited from the interviews with parents and teachers, ROBIN should be as easy to use as possible, so that children can play independently without always having to involve adults. ROBIN should also be robust against user errors, always asking for confirmation before shutting down or exiting a story.

Responsiveness: ROBIN should give children a clear feedback when they press a button or they say a sentence; the child should always know what to do to advance the story.

Support for multiple users: ROBIN should be usable by more than one child at the same time; specifically, we envision three reading modes: reading alone, reading with a peer, reading with an adult, reading with an adult and peers (siblings/classmates).

Tangibility: ROBIN should be tangible, small enough to be easily picked up or held by a child.

Aesthetic: ROBIN should not present as belonging to a specific gender, to appeal to both boys and girls, and it should be soft to the touch, easy to cuddle.

Music and lights: ROBIN should be able to play songs, as many of the patterns used in songs - such as rhymes, or sound repetitions - help children develop phonological awareness. It should also be able to display different coloured lights, as those are good clues to attract children's attention and memory retention.

Visual symbolic interaction: ROBIN should support a form of visual interaction made up of symbols such as stars and hearts, to reflect the children's predilection for stickers and emojis.

Emotional Support: Making children feel supported and helping them deal with emotions has a positive impact on learning - this can happen by asking questions about how they and characters in the story feel and showing them expressions of emotional states, moods and feelings, like in emoijs in response to situations and elements found in reading.

4 DESIGNING ROBIN

4.1 Physical attributes

ROBIN is around 30 cm tall, so it can be easily carried around by children. It is soft to the touch, with a vinyl exterior. The color is neutral, avoiding strongly gendered colors. While it has a generally humanoid shape, it does not have any specific facial features (see Figure 1); instead, it features a pixel matrix on the "face", allowing

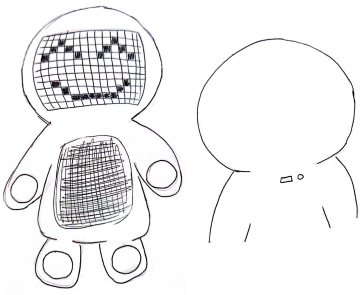

Figure 1: Front view of ROBIN, featuring the pixel matrix, the speaker and the buttons, and back view featuring the USB-C port and headphones jack

it to assume different facial expressions such as a smile (Figure 1); the body contains a speaker, while all four extremities feature LED lights and sensors that allow them to be used as buttons. These are also marked in Figure 1.

In our vision, children can interact with ROBIN both by touching the extremities and by talking, to accommodate different children's personalities. The symmetry of the design allows for ROBIN to be used by two children at the same time - for example, a child controlling the right hand and foot, and another controlling the left ones.

On the back (Figure 1), ROBIN features a USB-C port, allowing both for recharging - while many children's toys still use batteries, a rechargeable lithium battery is preferable both in terms of safety and environmental sustainability - and connecting to another device, for example to download new stories and songs. There is also a jack to connect a pair of headphones, allowing children to also use ROBIN in environments such as planes or cars. This feature is also present in Lunii, a radio-like toy for storytelling.

4.2 Functionality

ROBIN allows the child to either select a story by their name, or to listen to a random story chosen by the robot. We envision two possible modes of interaction: **dialogic reading**, which employs the PEER sequence, or **"choose your own adventure"**, each with four sub-modes: alone reading, reading with a peer, reading with an adult, reading with peers and an adult.

In each case, ROBIN starts telling the story; the storytelling is accompanied by different coloured lights, and by symbols that appear on the pixel matrix. The storytelling stops at regular intervals, and ROBIN asks the child a question.

The types of questions that are asked in the two different modes are different; in the dialogic reading, the questions prompt the child to say something about the story; in the "choose your own adventure" mode, questions allow the child to choose different paths in the story, and as such, there are not "right" or "wrong" answers.

The child can answer the questions either by speaking or by using the buttons on ROBIN's extremities; in the dialogic reading mode, if the answer is wrong, ROBIN repeats the question once more, if it is right, compliments the child and then expands the child's response by rephrasing and adding information to it, in accordance to the PEER sequence. In the "Choose your own adventure" more, the different answers lead to different paths in the story.

ROBIN can also play songs, both at the end of a story, and as a separate activity. The child will be encouraged to sing along, to encourage learning new words and rhymes through song. The songs will also be accompanied by coloured lights and images on the pixel matrix.

We understand that designing a prototype that would address all these different requirements and interaction models would be quite an ambitious endeavour. Therefore, we aim to start designing our prototype by focusing on a subset of the requirements, that will allow us to fill the broader gaps in the design and conduct a Wizard-of-Oz study. Specifically, our goal is to start designing for the voice-activated mode of interaction.

5 CONCLUSIONS AND FUTURE WORK

While we were able to extract many user requirements from our previous work, leading us to a first sketch of ROBIN, there are many gaps in the design that still needs to be filled. The aspects that we need to refine can be grouped into four broad categories:

Personalisation: What is the impact of personalisation on children's engagement with ROBIN?

Appearance and personality: What are the ideal characteristics of ROBIN, in terms of personality, perceived gender and voice?

Story content: What kinds of content work better for engaging children? How do children and adults transform them in personalised narratives?

Role of parents: What should the role of the parents be when using ROBIN with their children?

During the next year, we plan on refining our sketches and produce several prototypes; our work will be articulated in three phases.

5.1 Phase One: Co-designing with children and parents

We will conduct another cycle of co-design sessions in which children will be able to design their own ROBIN. In this phase, children will create sketches and physical low-tech prototypes using tools such as building blocks or modelling clay; drawing and creating low-tech prototypes are in fact co-design methods that have been used successfully with young children [11] [1] [15] [2]. We also plan on involving parents, by creating and circulating a survey to gather information about how they currently read with their children, and their insights on ROBIN. We are also looking at ways to involve parents in child-parent collaborative design settings, by proposing child-parent activities in a library setting and observe the dynamics of shared reading. We realise that this is very ambitious, as parents are very busy, and we are looking at ways to make this activity more attractive to them, by providing incentives and explicit benefits. This phase will help us refine our goals related to **personalisation** and **appearance and personality**. Depending on how much we will be able to involve parents, we will also delve further into the **role of parents**.

5.2 Phase Two: A Wizard of Oz approach

Following phase one, we will refine our design based on the insights provided by children and parents, and we will build a first prototype of ROBIN. We will then evaluate the prototype first in a pilot study, and then with a larger number of children. In this phase, the prototype will still be largely not-functional; however, as our users are very young, we plan on employing a Wizard of Oz approach, with researchers acting as ROBIN. This will also allow us to furtherly tweak the design by trying different approaches, such as different voices, shapes and personalities. This phase will helps us furtherly refine ROBIN's **appearance and personality** and give us insight into the **story contents**.

5.3 Phase Three: A Functional Prototype

Finally, we will create a functional prototype, using electronic components such as Raspberry Pi, with a working speaker and a pixel matrix to build a fully functioning robot. We are aiming to conduct a comparative evaluation against the original Tellie or similar market products, and to validate the findings from the previous phases by evaluating our prototype in a larger group.

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