Prototyping a Conversational Agent for Children's Play

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This research offers a structured approach to implementing a voice-based conversational agent for children aged four to seven years, aimed at facilitating playful movement and physical engagement, and enabling integration within kindergarten settings. The motivation to implement such an agent stems from the lack of comprehensive design guidelines for building meaningful interactions between conversational technologies and young users. As playtime continues to decline in childhood environments such as kindergartens, it is crucial to refocus attention on the importance of play and its various benefits, including support for cognitive, language, and narrative development. The study presents a detailed overview of existing research on conversational agents for children, along with a clear methodology entailing the steps for prototyping an effective, child-friendly scenario that can later serve as a reference during implementation. Subsequently, the research informed the creation of a prototype incorporating the developed storyline suitable for young audiences, while taking into account the technical considerations of designing such agents. The prototype underwent an evaluation phase with children to collect feedback on its effectiveness. Based on this feedback, the research generated recommendations for future design guidelines and product refinements.

Additional Key Words and Phrases: Conversational Agents, Voice-Based Interaction, Physical Play, Child-Computer Interaction, Story Design.

1 INTRODUCTION

Voice-based conversational agents (VCAs) are promising artificial intelligence technologies designed to engage users in conversation through natural language input and output [29]. Recently, the landscape of Conversational Agents has become increasingly complex [29], with their applications expanding in different domains such as healthcare [12], education [28], finance [8], and beyond.

Although VCAs increased their prominence in recent years, primarily in applications for adults, they can also offer valuable benefits for young children [19], as play is a fundamental aspect in childhood development. Conversational agents can assume various roles during play, ranging from planning and guiding the entire activity to taking on different peer roles such as a playmate [19] or supporter in collaborative storytelling [13].

Engaging in pretend play entails several cognitive abilities, including the symbolic transformation of different actions and surrounding objects [1], as well as employing imagination to interpret different scenarios and potential solutions within the play context. Extensive research has shown conceptual relationships between high-quality pretense play and childhood development [1, 11, 27]. Particularly, play-based experiences are important facilitators of perspective taking [1], encouraging children to engage in problem-solving, accomplish goal-specific tasks, and improve communication. Additionally, participating in imaginative play scenarios underpins language enhancement and supports the growth of narrative skills. For instance, an early study [11] designed to explore the relations between narrative structures and pretend play showcases that children involved in pretend play enactment of stories produced narratives with greater complexity than those exposed only to storytelling. Over the years, several theories about the play topic have emerged, such as the *Cognitive Theory of Pretense* [16] and the *Theory of Mind Development* [1, 4, 19]. Both theories were introduced to better understand the mental processes involved when a child is engaged in activities that are not real, but treated as if they are. Furthermore, these kinds of theories, which explore the mental workspace within the child's brain, help establish design guidelines of conversational agents that facilitate rich, play-based scenarios. Such cognitive frameworks also address the psychological side, which is crucial when prototyping a conversational agent for children, going beyond technical details to improve engagement and interaction.

However, despite the crucial contribution of play in children's development, technologies such as conversational agents lack proper customization for child users [20]. Owing to the scarcity of attention to this need, throughout this research, we prototyped a voice-based conversational agent that acts as an interactive play companion and promotes participation in physical activity among children.

Ideally, our solution for the agent incorporates 10 or more different storylines that engage children in physical play. However, to illustrate the concept of creating an appropriate and child-friendly scenario, we designed only a single example storyline. For a long-term perspective, the prototype enables future designers to regularly add new storylines weekly or monthly to sustain diversity and prolonged engagement between the agent and children. This approach provides a clear and practical example of a storyline that can serve as a reference, while supporting the long-term goal of enhancing the agent's diversity. First, we reviewed related work in the field of conversational agents. Then, we reported the results of the three studies that form the foundation of this paper.

2 PROBLEM STATEMENT AND METHODOLOGY

Conversational agent technologies are still not adequately tailored to children's developmental needs and often fail to account for ethical problems, such as over-trust and emotional attachment [20]. Furthermore, despite the impressive contributions of pretend play in children's development and the support for integrating play-based curricula for children, playtime in kindergartens is slowly fading [1]. Hence, we address the following research question:

How can a voice-based conversational agent intended to encourage imaginative and physical play be designed and implemented among children aged four to seven, so it can be effectively integrated into kindergarten settings?

The answer to the previously stated question emerged from three different research studies, focusing respectively on the story design, technical implementation, and testing phase of the agent.

Study 1 focuses on reviewing relevant literature, identifying design principles and theoretical frameworks, and using them to

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inform a story design activity, aimed at developing an effective storyline that facilitates physical play. The story design was supported by a peer workshop involving focus groups and co-creation activities with 11 peers, intended to identify diverse physical challenges across various story concepts. The study also demonstrates how to integrate the identified fragments of challenges and stories into an effective and child-appropriate storyline.

Study 2 outlines the technical considerations involved in implementing the conversational agent based on the storyline. The core technology is based on Python and a Bluetooth Speaker, controlled by one laptop and serving as the conversational agent. The study provides documentation of the agent's technical design.

Study 3 consists of an evaluation phase of the agent, involving five children aged four to eight. This stage focused on gathering key insights into the agent's effectiveness, including children's physical participation, agent performance, and emotional responses. The study highlighted how the feedback received can contribute to improving the efficiency of the prototype. The primary consideration was to assess how children responded to the narrative while evaluating the potential of the implemented idea. Therefore, to better understand the relationship between the type of responses and the story content, a qualitative approach was employed, as it was more suitable for the study.

The work was carried out under Research Ethics Review 241089 of the Ethics Committee Computer & Information Sciences of the University of Twente.

3 RELATED WORK

To gather scientific literature on the topic, several academic databases were used, including Google Scholar, ERIC Institute of Education Sciences, ACM Digital Library, and arXiv. To find relevant papers, a combination of terms such as 'conversational agents for children', 'technology-enhanced physical activity', 'AI ethics for children', 'Child Computer Interaction', and 'play', along with other related keywords, was adopted in the search process.

As mentioned above, increasing work is done on playful VCAs for children [20]. The well-established link between play and multiple positive outcomes [3, 19] has brought increased focus to the thoughtful design, implementation, and evaluation of conversational agents intended to facilitate interactions with children. There is a substantial body of literature on how conversational agents can enhance youth development and social engagement [9, 19]. An illustrative example is the research conducted by Pantoja et al. (2019) [19], which examined various design approaches for voice agents in high-quality social play. By exploring diverse setups and physical representations of voice agents - from tangible, portable, and static forms to app-based control and screen-based agents, within a Theory of Mind-style play framework - the research analyzed the trade-off among these representations and offered design recommendations for future voice user interfaces.

Furthermore, with the growing use of conversational agents by children, the research is becoming increasingly oriented toward enhancing their design to promote ethical interaction, while acknowledging kids' special needs regarding moral considerations [20, 25]. Recent research [20] highlights several ethical challenges in designing technologies for young users, including concerns about data protection, privacy, and language use. The paper advocates for the use of the Assessment List for Trustworthy AI (ALTAI) as an ethical guideline while complying with a set of key requirements, such as human agency and oversight, transparency, technical robustness, diversity, non-discrimination, and fairness. Additionally, concerns about children's over-attachment and over-trust, which stem from children's different understanding of the world [20], are reiterated in Van Mechelen et al.'s (2020) [25] research on ethics in child-computer interaction. While identifying eight different types of ethics, Van Mechelen et al. [25] emphasize the poor definition of ethics within child-computer interaction research and advocate for greater scrutiny in developing its theoretical foundations.

Notwithstanding these contributions, current conversational agents are insufficiently tailored to children's needs. To begin filling this gap, this research aims to explore the broader opportunities of conversational agents for children, focusing on supporting children to participate in physical activity.

4 STUDY 1 – PEER WORKSHOP TO DESIGN A STORY

4.1 Theoretical Grounds to Inform Design Guidelines

As pretend play has several benefits in children's development [1, 11, 27], it is crucial to consider these when designing an engaging storyline for children, and, by extension, a meaningful interaction with the agent. In this regard, the creation of an effective storyline that enhances physical play can be informed by established theoretical frameworks that explore mental processes around children's engagement with pretend play, as well as by practical design principles reinforced through co-creative activities.

We build our design session on the theories of (1) *Tools of the Mind*, inspired by [1, 4, 19], and (2) the *Cognitive Theory of Pretense*, inspired by [1, 16]. In addition, we drew on two more guidelines, inspired by the literature: incorporating directives into the story (3) (*Direct Queries vs. Directives*) [24] and maintaining a friendly narrative flow (4) (*Friendly Playmates*) [19, 24]. For a detailed description of the design criteria, see Appendix B. The theoretical foundations for high-quality social play informed the inclusion of imaginative scenarios, pretend actions to facilitate rich fantasy play, explicit directives, and positive reinforcements as design guidelines.

With co-creation design gaining recognition in recent years due to its numerous benefits [22], we applied the theoretical frameworks in a peer workshop involving 11 participants from the Computer Science field. The workshop consisted of two co-activities: one aimed at generating practical story and child-agent design principles reinforced by peers, and another focused on co-creating imaginative story fragments consisting of fun and achievable physical activities for children aged four to seven. The main goal of the workshop is structured according to the Golden Circle Theory of Simon Sinek [23]: *WHY* - to promote physical movement through whimsical stories, *HOW* - through brainstorming, collaboration, and co-design activities, and *WHAT* - a collection of story fragments featuring different physical challenges.

The theoretical foundations were presented to peers in the form of a story-based application, where each of the four research theories was illustrated through a corresponding story fragment (see

Appendix C.2). In the end, the illustrative fragments were compiled into a full story that served as inspiration during the co-activities. See Appendix C.3 for the story example.

4.2 Generated Results

During the session, we used multiple canvases designed in alignment with the workshop's objectives, along with toys and a set of story concept cards to inspire creativity. They were effectively employed by peers to generate valuable outcomes. For a detailed overview of the materials used, refer to Appendix C.1. The results include two sets of completed canvases, each corresponding to a co-activity. The first set comprises 11 different sheets containing new story and child-agent design principles generated by peers. The second set consists of 44 story fragments featuring various physical challenges, distributed across 11 distinct story concepts, and subsequently used to create an engaging storyline for children. The key outcomes of the workshop, including peer participation and examples of completed canvases, are illustrated in Figure 1.

4.3 Results Analysis

The results were organized into tabulated data to support a thorough analysis, based on manually transcribed audio recordings and video analysis. The focus was on materials' efficiency in identifying physical challenges and the resulting story fragments.

4.3.1 Resource Efficiency in Generating Physical Challenges. Twenty story concept cards were provided for inspiration (see Appendix C.4). As a quantitative breakdown of the concept cards' effectiveness, seven out of 11 participants used one of the proposed concepts when creating their story, three created themes similar to the proposed ones (e.g., *Treasure Hunt Adventure*, *Big Castle on Medieval Times*, *Castle Escape*), and one participant proposed a new concept: *Ladybug Exploration*.

Moreover, toys and props proved valuable in co-creating physical challenges. A thorough analysis of video and story fragments identified 13 different toys featured in the narratives, including the green frog, the cat stick, and the police car. For instance, the green frog toy, which was close to a specific participant, was referenced in his story fragment: *Pretend you're a frog and jump like one! Jump, jump, jump!* Another example is the inclusion of a cat character in a story fragment, as the participant had the cat stick in front of him: *You are a small block cat inside the haunted woods*. During the analysis, toys were grouped into four categories based on the story element they inspired: *Story Setting*, *Character Role-Play*, *Story Character*, and *Story Action*. Four out of the 13 toy usage entries, along with the story elements they inspired, concepts they were associated with, and the corresponding story fragments, can be seen in Table 1. Participants also acknowledged the toys' contribution to the creative process: *All the toys around were a nice inspiration!*

Moreover, the creative activities were supported by a set of *Method Cards for Movement-based Design* from MeCaMInD, which were strategically selected to facilitate playful movement [26]. The selected categories include *Basic Movements*, *Play and Sports Discipline*, *Play Elements*, *Persona*, *Environment*, and *Metaphor* cards. Multiple participants were observed using them repeatedly throughout the activity.

4.3.2 Thematic Analysis: Story Patterns and Recurrent Elements. A thematic analysis of the collected story fragments was conducted to explore different patterns and recurrences that could support the development of a complete and compelling story for children. The examination process is inspired by Braun and Clarke's Thematic Analysis [5]. Initially, reviewing the story fragments facilitated the identification of surface-level patterns, such as the recurring goal of finding a treasure or reappearing settings like jungles or castles.

The next step was coding the collected data, paying attention to specific parts of the content relevant for analysis. Seventeen distinct code categories were selected, each having a specific purpose related to different aspects of the story fragments, such as goals (e.g. *Mission-based Tasks, Escaping, Escape Mechanisms, Exploration*), actions (e.g. *Basic Movements, Dexterity, Strength*), characters (e.g., *Animals, Humans, and Other Creatures*), settings (e.g. *Fantasy/ Imaginary Worlds, Adventure Locations*), and supportive feedback (e.g., *Positive Reinforcements, Encouragement, Compliments*). As an example, the codes *Magical Help* and *Magic Items* helped to identify the use of magical items that either support progress or serve as obstacles for the protagonist in the story fragments. Magical elements and supernatural creatures often aided the protagonist. Examples include sirens offering help (*Look, the sirens have come to help*), a wizard giving suggestions (*Oh, no! Look below you! The floor is lava! Zoli, the wizard, tells you to jump from stone to stone!*), and the use of a magical candy to cover the jungle adventure (*He can't escort you, but he's giving you a magical candy that turns you into a frog for a couple of minutes, enough to cover your jungle adventure*). For each of the seventeen code categories, such concrete story examples were collected during the analysis process, resulting in 116 story citations, grouped accordingly. The full set of codes and illustrative examples is available as supplementary material.

As a third step, we drew on the design principles created during the workshop. We selected the most relevant ones (see Appendix C.5) and formulated sixteen themes under which the previously mentioned codes could be included and grouped: *Characters, Magic and Myths, Character Role-Play, Goals, Encouragement and Supportive Feedback, Physical Challenges, Problem-solving tasks, Obstacles, Collaboration and Teamwork, Step-by-Step Instructions, Environment, Recurring Concepts, Settings Patterns, Characters Patterns, Actions Patterns*, and *Items Patterns*. From the themes, sixteen general patterns emerged across the story fragments. Due to space constraints, three patterns are presented below. See the Appendix C.6 for the full list.

- Character Role-Play: Stories involve embodied role-play, requiring the protagonist to take on different identities. Imitating different animals and creatures is a common form of transformative action (e.g., *turning into a frog, pretending to be an explorer*).
- Goals: Three common types of missions were identified in the stories: exploration, rescue, and escape (e.g., *saving the royal horse, escaping the volcano, exploring the cave*).
- Step-by-Step Instructions: Fast-paced, multi-step sequences were a recurring pattern in several stories (e.g., *jumping, crawling, hiding; move forward, and stop, move left and forward, wait, move right*).

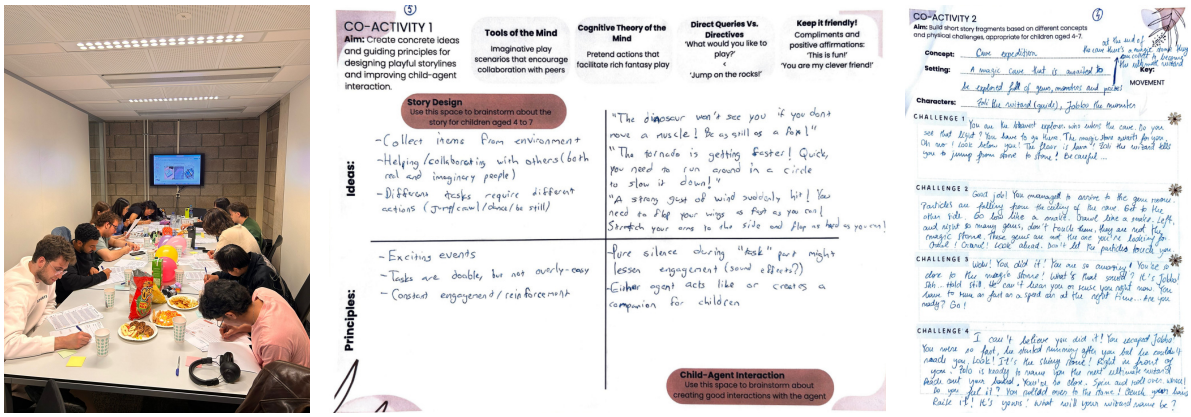

Fig. 1. From left to right: Peers participating in co-activities; Sample canvas from co-activity 1; Sample canvas from co-activity 2

Table 1. Connections between toys and story fragments

Toys/ Props	Concept	Story Element Inspired	Story Fragment
Sticker Cards (Sirens)	Treasure Hunt Adventure	Story Setting - Path to destination	'You have to cross the siren's bay.'
Lion Stick or Lion Toy	Tropical Island	Story Action - Animal-Inspired Action	'Roar like a lion to scare the storm away!'
Green Frog	Treasure Hunt Adventure	Character Role-Play	'Pretend you're a frog and jump like one!'
Sand Toys	Treasure Hunt Adventure	Story Character - Obstacle	'Take out your sword! Fight the sandworm!'

4.4 A Full Story Creation

Several story fragments of challenges created during the workshop were combined into a unified and engaging storyline designed for children aged four to seven. This integration is grounded in developmental psychology theories, such as Piaget's *Theory of Cognitive Development* [18], and in basic principles of children's story comprehension, enhanced by narrative simplicity and coherence.

A space-themed play scenario from *Tools of the Mind: The Vygotskian Approach to Early Childhood Education* [4] served as the initial inspiration for developing the storyline: *We are going to make a space walk and look at moon rocks. We're scientists on the ship.* The process was guided by the selected story and child-agent interaction design guidelines (see Appendix C.5), identified during the results analysis process, along with multiple physical challenge ideas drawn from the 44 story fragments generated during the workshop. The full story contains 15 text fragments, including 13 physical activities that children must perform to accomplish the final mission of saving their friend, Nano. Figure 2 presents an example of a challenge: children pretend to climb trees by jumping and stretching their arms to collect ten bananas and give them to the monkeys in exchange for their friend, Barty. Refer to the Appendix C.7 for the full storyline.

To ensure story narrative coherence and effectiveness, the *Proppian Taxonomic Model* was applied [6]. Eleven distinct Proppian narrative functions were selected, corresponding to three story phases: the narrative setup (*absentation, interdiction, villainy, departure*), the adventure progression (*violation, struggle, transfiguration*), and the narrative closure (*victory, returns, solution, recognised*). For an overview of the selected Proppian functions and their application within the story, see Appendix C.8.

(Challenge 4: Collecting 10 Bananas) That was amazing, explorer! Your power to clear the vines is incredible! Now you are deep in the jungle. But wait, look around…. Where is Barty? Barty, where are you? Look up! Monkeys are jumping from tree to tree! Oh, no! They have taken your friend, Barty! Unbelievable, what a twist in your adventure! But wait - the monkey king, Mojo, says you have to climb up the trees and jump from branch to branch to collect 10 bananas. He will release Barty in exchange for the bananas. Climb the trees! Jump, jump, really high! Collect the bananas by stretching your arms and jumping from tree to tree! Come on, you've got 9 bananas! Just one more! Jump! Jump high and stretch your hands one last time! **(active music starts playing)**

Fig. 2. One fragment of the final designed story about space

The workshop's results analysis was used to identify and select recurring concepts (e.g., treasure hunt), characters (e.g., monkeys), environments (e.g., jungle, castle), and magical elements (e.g., teleporting flower, sword, gems, treasure) that supported the final story creation. The story fragments were combined based on the resulting pattern rules and their thematic commonalities (see Appendix C.6).

Furthermore, Jean Piaget's *Theory of Cognitive Development* about the pre-operational stage guided the story creation process [18]. As children in the pre-operational stage (ages two to seven) are not yet able to understand complex logic, reason egocentrically, learn through previous and familiar experiences, and attribute life-like qualities to objects [18], the guidelines for combining physical challenges emphasized story linearity and clarity, the presence of repetitive elements, and the use of anthropomorphized characters. Applying these guidelines, the final story has a simple and clear narrative flow that follows a hero's journey, inspired by the Proppian approach [6]. It includes a recurring task of collecting gems and placing them on the map, along with anthropomorphized characters selected based on recurring patterns (e.g., talking animals such as

Mojo, the monkey king, who releases Barty in return for bananas, and magical objects such as the teleporting flower).

Thus, integrating story fragments proved effective in delivering an engaging storyline for children, grounded in theoretical frameworks that support both children's developmental needs and ease of story comprehension. The resulting narrative was implemented in the conversational agent as highlighted in the next section.

5 STUDY 2 – PROTOTYPING THE AGENT

5.1 System Architecture Overview

Although full mixed initiative, as a norm for human-human interactions, is difficult for dialog systems [10] and considering young children as primary users, the storyline developed in **Study 1** (see Appendix C.7) was implemented using a unidirectional, voice-based agent with a full conversational initiative [10] and a focus on expressive speech output. A system-initiative approach [10] was adopted in the implementation, with the agent encouraging children to participate in various physical challenges through directives and friendly acknowledgments. The technical design was complemented by a multimodal strategy incorporating music and sound effects.

The technical components include Python-based control logic, the ElevenLabs API, and the pyttsx3 library for Text-to-Speech, a JSON story format for a modular approach, and the pydub library for audio processing. These are organized into four interconnected modules (*input module, audio alignment module, text-to-speech module, output module*). The diagram in Figure 3 illustrates how the story-driven agent is responsible for processing the story narration, converting it to speech with integrated music and sound effects, and outputting it through a Bluetooth speaker. Further details on each technical aspect are presented in the following sections.

5.2 Story Format and Representation

To separate the narration content from the implementation logic, the story is structured in a modular JSON format, which is loaded by the agent and fragmented into three story phases, as illustrated in **Study 1**: an introduction, corresponding to the *narrative setup*; a set of 13 chunks of story data, each representing a challenge in the *adventure progression*; and an ending, corresponding to the *narrative closure*. The JSON format enables better data management and accessibility by allowing each fragment of challenges to be associated with its corresponding details, such as description, narration text, music audio, and ID, for further sequencing and playback. To enable a multilingual design, the story is available in JSON format in both Dutch and English.

5.3 Text-to-Speech Conversion and Voice Perception

The agent's development began with basic, robotic voice generation, facilitated by the pyttsx3 [1] Text-to-Speech conversion library. While enabling the storyline to be played in an offline environment, this approach delivers a neutral voice lacking in intonation. As previous research highlights that subjects' perceptions are sensitive to a conversational agent's interaction style [2], the next step in implementation focused on carefully designing the agent's voice to align with a conversational style that matches children's expectations. The aim was to optimize expressiveness, intonation, and naturalness in the voice to enrich the experience for young users. This was achieved using the ElevenLabs Text-to-Speech API [2], which enables access to a variety of voice styles featuring nuanced intonation, emotional awareness, and dynamic pacing across multiple languages. Several voices with animated intonations and pacing were selected for both English and Dutch. Given that maternal voices play a crucial role in children's brains and are more familiar than other sounds, while being more effective in capturing children's attention and in evoking responses [15], a female voice was ultimately selected for the agent to enhance relatability and foster a sense of connection. This decision was further supported by peers' suggestions during the workshop.

5.4 Music and Sound Effects

Given that users prefer to interact multimodally rather than unimodally [17], the subsequent technical step involved integrating audio-based complementary modalities into the voice-based agent. To facilitate children's participation, enhance their interest in the story, and yield a synergistic blend of multisensory experiences, including story comprehension as a cognitive process and auditory stimulation, each physical challenge was accompanied by music and sound effects. The multimodal design of the agent was inspired by Oviatt's *Ten Myths of Multimodal Interaction* [17], to support gesture expression and increased body movements from children. The prototype includes a collection of 13 distinct audio clips, selected from open-access music and sound effects libraries, each one aligned with a corresponding physical challenge. For instance, the sandworm fighting scene is complemented by a sword-effect sound, the challenge of removing the jungle vines is accompanied by jungle-themed music, and the dancing activities are paired with captivating, lively tracks appropriate for dynamic movements. The audio clips were manipulated and interleaved within the story text using the pydub library [3], which allows seamless audio processing in alignment with the JSON-based story representation. Moreover, incorporating music and sound effects after each physical task promotes effective narrative pacing, providing children with additional time to understand and execute the task successfully.

5.5 Limitations and Solutions

A limitation encountered during implementation was that consecutive ElevenLabs API calls, required to convert successive story fragments into speech, introduced delays between audio clips and the continuation of the story narration. To overcome this inconvenience and provide a better experience for children, each data chunk and its corresponding music or sound effect were recorded as separate files and then merged into a single MP3 file. Since ElevenLabs uses a subscription model with character-based limits, this approach has several advantages, including running the agent in an offline environment and reducing character usage in case of repetitive plays, while maintaining a natural-sounding and animated voice.

[1] https://pypi.org/project/pyttsx3/

[2] https://elevenlabs.io/docs/quickstart

[3] https://pypi.org/project/pydub/

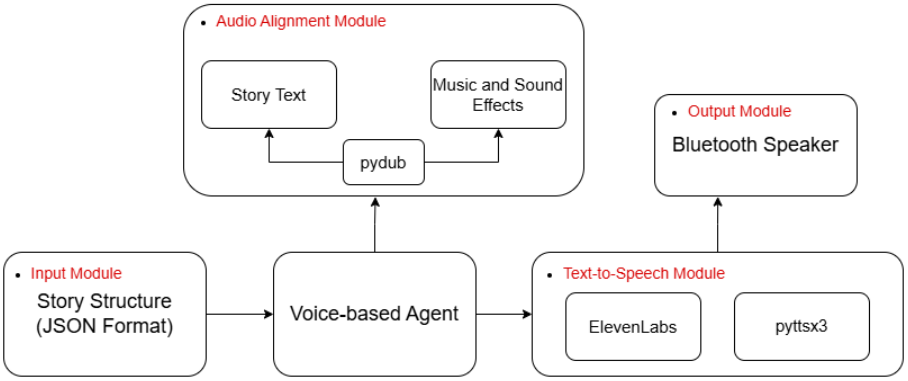

Fig. 3. System Architecture

6 STUDY 3 – TESTING THE PROTOTYPE

In light of children increasingly becoming tomorrow's power users of technologies, and their growing active participation in design processes [7], the prototype was evaluated guided by the *Child as Tester Framework* [7]. The overall goal was to gather feedback from children and daycare professionals that can be integrated into future product refinements. Ensuring consistency with previously conducted studies, the motivation for the testing session was to validate the developed story design's potential to promote physical play and to appraise the efficacy of the technical approaches used in its implementation. The main goal was pursued through a synthesis of structured game-play with children and semi-structured sessions, incorporating the researcher's observations, open-ended questions, and interviews. The testing procedures' trajectory and results are detailed in the following sections. The outcome of the evaluation phase comprises a set of observations and answers concerning the listed goals of the inquiry, serving as validation metrics to be assessed: *Content and Story Narration*, *Physical Engagement and Impact on Children*, and *Agent's Performance and Usability*.

6.1 Procedures and Participants

The evaluation phase took place at the 'De Vlinder' daycare center at the University of Twente campus. After receiving parental consent, we tested the agent with five children aged four to eight years, who were observed by a daycare professional. First, the research topic and the session's goal were described to the daycare professional. Two facilitators, a student and a researcher in the field, participated in the activities and assisted in guiding the session, while the main author observed the test and took notes. After setting up the agent, we introduced ourselves to the children and explained the purpose of the game. Before starting the session, each child was given a map (see Appendix D.3), designed in alignment with the story's content. The map simulates two moments in the experience when the children collect two gems and place them on designated *X* spots as a reward for completing a set of challenges. Thereafter, the agent was deployed, and the children engaged in each challenge. In the next phase, the researchers asked the children a series of short, open-ended questions about the overall experience, followed by an interview with the daycare professional.

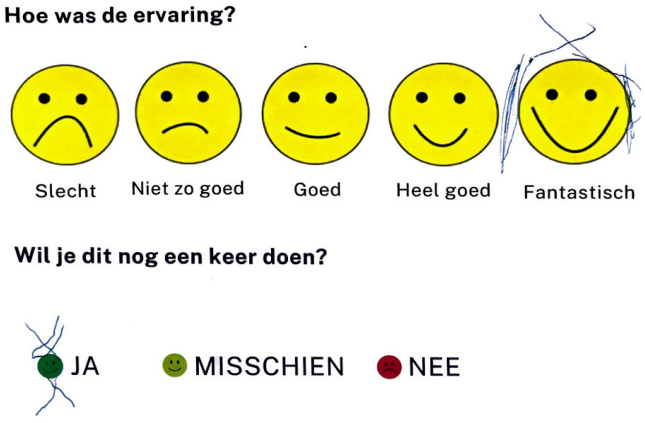

Fig. 4. From top to bottom: Smileyometer card; Again Again Table card

6.2 Measures

The maps served as valuable tools for measuring how well the children understood the story's mission. During the experience, an observational sheet was completed for each story fragment. We focused on various observational points, including story flow and comprehension, children's attention, the difficulty of the challenges, physical engagement, expressed emotions, and the impact of music and sound effects. For a complete overview of such an observational sheet, refer to Appendix D.1. In addition, we used the Smileyometer and Again Again Table methods to gain insight into how the children felt during the experience. The cards for these methods were inspired by the research of Read and Horton [21] and are shown in Figure 4. In addition to the questions on the cards (*How was the experience?* and *Would you like to do this again?*), children were asked three more questions: *What did you like the most about the game? What didn't you like about the game?* and *Was anything too confusing or hard?* The semi-structured interview with the daycare professional consisted of 11 questions, designed in alignment with the validation metrics. Examples of the questions addressed include: *What did you*

think of the story or content of the agent? What did you think of the physical challenges? What did you think of the voice of the agent and the music or sound? and *What would you remove or change?* For the full list of interview questions, refer to Appendix D.2.

6.3 Results and Implications

We began by transcribing the audio recording of the daycare professional's interview. The results were analyzed using the 15 completed observational sheets (see Appendix D.1) and the affinity diagramming technique [14], spatially clustering insights on sticky notes according to the predefined validation metrics (see Appendix D.4).

6.3.1 Content and Story Narration. Observations suggest that children generally understood and successfully followed the story challenges. However, certain tasks presented minor difficulties. The first challenge (*Jumping Through the Portal*) caused some confusion, as the children were not yet familiar with the agent's instructions. Nonetheless, all ultimately completed the activity. Likewise, Challenge 11 (*Getting the Treasure*) was notable as the most difficult. The instructions unfolded too quickly, with only three out of five children able to complete the challenge independently, requiring facilitators to further exemplify the actions. Thus, we suggest reducing the level of difficulty in this case by simplifying the instructions. With respect to following the story, two moments stood out. During Challenge 5 (*Save Barty from the Monkeys*), the children showed strong adherence to the agent's instructions by getting on the floor and pretending to crawl. Moreover, Challenge 10 (*Distracting the Galactic Guards*) captured a surprising response: upon listening to the agent's instructions (*Get the rocks, throw them away!*), the children expressed a desire to throw the physical rocks. To avoid any potential risks, the story content should not reference any physical props distributed to the children that could be used inappropriately. Additionally, the results indicate that the map and the gems were successfully used by all children, with help from the facilitators. Even so, to prevent a rushed unfolding of events, we suggest extending the music duration for these challenges, allowing more time for facilitators to distribute the props and for children to use them.

Children's attention was generally high during the experience, particularly when they engaged with the maps and the gems. They did not talk to each other, but instead carefully listened to the story. As a good practice for future content, we suggest including more props in the story that children can interact with. However, a decrease in attention was noted during Challenge 3 (*Removing the Vines*), likely due to the opposite actions: *swing your arms* and *don't make too much noise*. Thus, a design suggestion is to avoid constructing the story around contradictory statements that may confuse young audiences. Furthermore, to maintain a natural flow, the story fragments ideally have even timing. For example, the first challenge (*Jumping through the Portal*) felt rushed and short compared to the introduction, which can be reduced to prevent a decrease in children's attention.

Children confirmed that the story instructions were clear and that they did not feel nervous during the challenges. The daycare professional described the story as *really fun* and *exciting enough for all ages*. However, they suggested simplifying the language, as they acknowledged some words that might be difficult for children to understand (*Portal - what is that?*). Length-wise, they recommended providing longer stories for the agent, noting that children also like repetition: *it could be longer*, and *they love repetition*.

6.3.2 Physical Engagement and Impact on Children. The children were physically engaged in most challenges, with four standing out in this regard: Challenges 4, 5, 10, and 13. In terms of difficulty, one of the 13 challenges was categorized as *hard* (Challenge 11), two as *medium* (Challenges 1 and 3), and the rest as *easy* to complete. Refer to Appendix C.7 for the list of challenges. During the experience, the predominant emotions were enjoyment and happiness, and the physical engagement duration was generally long for each challenge. Furthermore, the music and sound effects had a positive impact on children's engagement and movement intensity, with effects observed in 10 of the challenges. For instance, two children were initially not that active in Challenge 3, but they all began to move once the music started to play. Music also intensified movement, particularly in Challenges 12 and 13, where children waited for the music to dance, and in Challenge 8, where the sword sounds enhanced their fighting moves. One child even imitated the sword sound aloud. Children especially enjoyed *the jungle part*, *dancing*, *crawling*, *jumping*, and *escaping the prison*. Overall, they liked the experience, with the Smileyometer cards recording two *very good* and three *fantastic* responses, and the Again Again Table cards showing four *yes* and one *maybe* response (see Figure 4). Moreover, when asked about the physical challenges, the daycare professional described them as *enthusiastic* and *fun*, highlighting activities such as *crawling*, *climbing*, and *jumping*.

6.3.3 Agent's Performance and Usability. The agent performed well, with a smooth and uninterrupted story. Since the children were presented with a lot of information in the introduction, a brief pause was added before moving on to the challenges. However, for future deployments, the agent allows for additional pauses when needed, depending on the children's level of confusion and comprehension. Moreover, the daycare professional confirmed that this type of technology is easy to use and a welcome addition in kindergartens, *alongside other things*. For kindergarten integration, she recommended embedding the agent in a toy animal to make it *more fun for children* and, at the same time, *more real*. She also suggested a possible deployment in outdoor environments, such as a forest, and proposed extending the agent by incorporating a fun story for toddlers aged three or four. She likewise believes it is important to help children during the game by playing with them, stating that *they'll participate more enthusiastically* that way. For the full interview answers, refer to Appendix D.2.

7 DISCUSSION

The findings of this research bring to light the immersive capability of a voice-based agent that adopts the role of a storyteller in encouraging children to play and engage in physical movement. The evaluation results highlighted that children enjoyed the experience and offered suggestions for improvement, thereby fulfilling the promises set out in the **Introduction** section. They confirmed the initial hypothesis that embedding a well-designed story with diverse

challenges into the system is an effective approach to promote movement in structured environments such as kindergartens. However, to mitigate the limitation of a small sample size that undermines generalizability, the prototype could be tested over the long term in centers with more children. Although the evaluation phase included only a few participants, the collected results seem valuable when the goal is to understand the types of responses and to assess whether the approach represents a worthwhile direction for research. These insights can be used to refine the story and the interactive system before proceeding to a more systematic and quantitative analysis of their impact on children. Of course, the system for real use can also be implemented in a more robust manner, with additional stories developed using the same approach. Integrating multiple stories into the system could make this technology even more compatible with professionals' routines, supported by a front-end component designed for story selection. Teachers could then select the story fragments they want to deploy based on motor development goals and the activities planned for the children. Other than that, the spectrum of avenues to improve the agent's functionalities remains broad, allowing for future extensions to be investigated in the field and raising richer points of discussion.

7.1 Speech Recognition Integration

An interesting direction for optimization would be to incorporate the speech recognition tool as a new capability of the agent. This would implicitly introduce new story-design implications that need to be considered as the agent evolves from a storyteller into a collaborative partner. Rather than presenting all the challenges sequentially, the agent could offer children alternatives for deciding and shaping the story's unfolding. As an example within the context of our story, the agent could ask children: *To earn the next gem, would you like to become a jungle explorer or a Dune Captain?* The agent is required to play out the challenges corresponding to the selected pretend character. Therefore, this approach would pose new challenges to be addressed, such as ensuring that the agent can fully capture children's exact responses and offer an accurate progression of story narration based on them. Achieving good accuracy in voice recognition would also require thorough attention to the children's age range, as the responses of very young audiences can be unpredictable and tricky to capture, especially when introducing this technology into a kindergarten classroom.

7.2 Giving Power to Children and Teachers

Another avenue for future research is allowing users to generate content for the agent. Teachers and staff members in kindergartens can employ our design activities from the first study to co-create new stories with children, fostering a sense of collective ownership and contribution to the agent. To achieve this, the resulting stories ought to be easily integrated into the agent, without requiring help from designers or developers. We suggest two different approaches for consideration. First, a simple interface can be integrated to assist teachers in inputting their newly created stories, with the latest features supporting text uploading and successive story conversion. A second approach would be to input the stories using the above-mentioned speech recognition tool, enabling teachers and children to speak their content while the agent is responsible for converting it to text, according to the predefined story format. Allowing teachers to create their own stories can help tailor the agent's narratives to different classroom activities, holiday themes, or seasonal events.

7.3 When the Product Supersedes the Process

The peer workshop was extremely valuable in generating story challenges for children and producing interesting results. However, an intriguing question emerges: can it be replaced by the agent itself, once the technology reaches a potentially new level of deployment in kindergartens? By giving users the power to add new story content weekly or monthly, might the agent reach a level where it can learn from them and produce its own content, adapting to children's and teachers' patterns of creating stories, or perhaps even to children's preferences for characters or favourite story themes emerging from their own creations? In this regard, we propose an exciting solution for a remarkable evolution of this technology: integrating machine learning and natural language processing (NLP) [10] to build an AI model that can be pre-trained to learn, deduce patterns, and dynamically create its own content. In this case, the technology design imposes new challenges that must be considered, such as the extent to which the designer wants to mitigate the human-mediated activities and contributions in favor of a fully automated process. As the initial creators of the agent, we suggest preserving the input of peers, teachers, and children by encouraging a hybrid design that integrates both human and technical contributions. Participants' involvement can not be superseded in the design, as it preserves authenticity in storytelling and considers children's unique needs, which an AI might not fully embody.

8 CONCLUSION

In this paper, we show how to design a sequential, child-friendly narrative and effectively integrate it into a voice-based agent that promotes physical play among children aged four to seven by incorporating music to stimulate movement. The research was guided by a partnership with children and their daycare professionals, enabling us to identify and suggest future guidelines to improve the agent's efficiency. The findings of the research highlight the intuitive operation and practicality of the technology, implying its effective and seamless integration into kindergartens. This work adds to the field of Human-Computer Interaction while opening new directions for better designing technologies for children. This contribution points to a bright future for this type of agent, which could be acknowledged as an educational product in kindergartens and well-tailored to children's developmental needs. Considering the existing and potential improvements based on our findings, this study points to greater advancements in the field that could gradually fill the current gaps in these technologies.

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A APPENDIX A - ADDITIONAL REMARKS

During the preparation of this work, I used Grammarly and Overleaf to check for grammar and spelling mistakes, along with generative AI, solely for code debugging purposes. After using these tools/services, we thoroughly reviewed and edited the content as needed, taking full responsibility for the final outcome.

B APPENDIX B - DESIGN CRITERIA

A detailed explanation of the theories underlying the design guidelines is provided below.

Tools of the Mind Framework (inspired by [1, 4, 19]):

- Vygotskian Approach to High-Quality Social Play
- This approach suggests that children's cognitive, social, and emotional development occurs primarily through imaginative social play and collaboration with peers.

Cognitive Theory of Pretense (inspired by [1, 16]):

- Suggests that the phenomenon of pretense can be explained through a 'separate mental workspace' within the human brain.
- Since pretense plays a vital role in young children's lives, the storyline can incorporate pretend actions that children can perceive as real, facilitating rich fantasy play.

Direct Queries Vs. Directives (inspired by [24]):

- Based on previous research, direct queries such as 'What do you want to play?' elicit fewer responses from users than explicit directives like 'Jump on the rocks!'

Friendly Playmates (inspired by [19, 24]):

- There is a need for the storyline to balance positive reinforcements with task-oriented speech.
- Providing compliments ('This is very fun!', 'You are my brave friend!') is crucial to ensure that the agent does not come across as too bossy or excessively directive.

C APPENDIX C - PEER WORKSHOP

This section provides additional information and materials on the peer workshop.

C.1 Appendix C.1 - Workshop Materials

Figure 5 shows the empty canvases distributed to peers during the first and second co-activity. Figure 6 presents several inspirational resources used, including concept cards, movement cards, and various toys and props.

C.2 Appendix C.2 - Theory into Story Fragments

The application of each theory through a story fragment is illustrated below:

Tools of the Mind (inspired by [1, 4, 19]):

- Story Snippet: 'You are an astronaut on a spaceship! Your scientist friend, Bumy, needs your help with an important discovery. She found strange, red moon rocks that she wants to explore, but her space suit is damaged. To help her, you need to spacewalk together with Timo, your astronaut friend, by jumping from rock to rock, without touching the ground! Collect the red and shiny stones at the end of the path and bring them back to the spaceship to complete Bumy's mission!'
- How it applies: Imaginary peer helping - help Bumy with her discovery and imaginative social collaboration - accomplish the mission with Timo, the astronaut friend

Cognitive Theory of Pretense (inspired by [1, 16]):

- Story Snippet: 'What a tough mission, but you completed it brilliantly! Great job, astronaut! Wait… did you hear that? Oh no, no! The systems in your spacesuit are failing, and you run out of oxygen! You need a new plan! To survive without a suit, pretend you are a Moon Creature, a mysterious being with glowing skin in different colors like silver, red, and blue, that lives between the craters. Crawl low to the ground like a Moon Creature, jump over the craters, but try to be silent - you don't want to be captured by space explorers! Make sure you reach the spaceship safely!'
- How it applies: New mental workspace - Children transform themselves into Moon Creatures by adopting a new identity

Direct Queries vs. Directives (inspired by [24]):

- Story Snippet: 'Great job saving your life, astronaut! You can take a rest now… or maybe not! Warning on the board, warning on the board! A meteor shower is approaching! Run now - run fast, fast! Look to your left, there are some magic energy blocks you can use to protect the spaceship! Grab each block and stack them quickly to build a strong fortress for the ship before the meteors arrive!'
- How it applies: No questions in the storyline and inclusion of different directives to guide the activity - 'Run now!', 'Look to your left!', 'Grab each block!'

Friendly Playmates (inspired by [19, 24]):

- Story Snippet: 'Mission accomplished! Your power is amazing, astronaut! I am proud to have such a smart and brave friend like you! The fortress you built is the strongest one on the entire Moon surface! Oh, wait, what's that sound? A meteor has hit your fortress! But your fortress was so powerful that it destroyed the meteor on impact! Wow! The explosion created magical particles that are flying through space! All of a sudden, you and your spaceship are teleported to a tropical island. Look, the spaceship has transformed into a boat! Jump, jump higher to climb into the boat and start a long-deserved vacation on the sea!'
- How it applies: Inclusion of compliments and positive affirmations - 'Your power is amazing, astronaut!', 'I am proud to have such a smart and brave friend like you!' and maintaining a friendly narrative flow

Table 2. Story Concepts

Story Concept	Chosen as Main Concept
Magic School of Wizards	No
Jungle Exploration	Yes
Ocean Diving	No
Tropical Island	Yes
Dinosaur Safari	No
Time Travel Adventure	Yes
Animal Rescue Safari	No
Mountain Mission	No
Science Lab	No
Volcano Island Escape	No
Castle Quest	No
Underwater Treasure Hunt	Yes
Magical Garden World	No
Cave Expedition	Yes
Desert Adventure	No
Haunted Woods	Yes
Maze Adventure	No
Lava Lake Mission	Yes
Puzzle Island Challenge	No
Time-Ticking Tower	No

C.3 Appendix C.3 - Story Example

The provided story example can be seen in Figure 7.

C.4 Appendix C.4 - Concept Cards

The provided story concepts, and participants' selection can be seen in Table 2.

C.5 Appendix C.5 - Selected Design Guidelines

The design guidelines used in the thematic analysis, along with the themes they generated, are presented below.

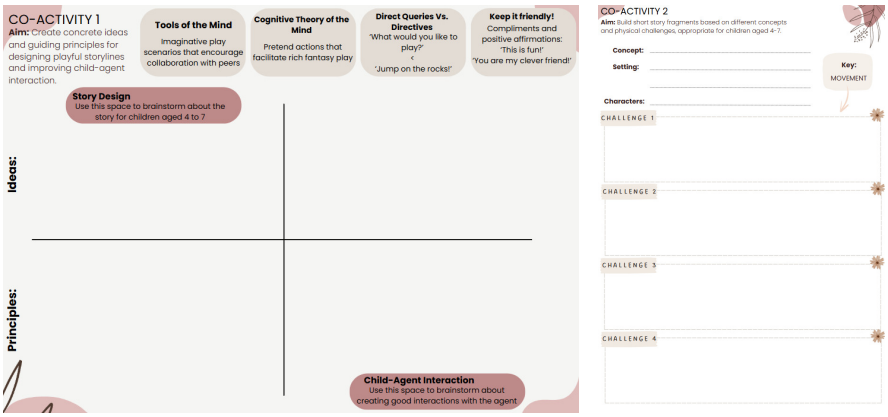

Fig. 5. From left to right: Empty canvas from co-activity 1; Empty canvas from co-activity 2

Fig. 6. From left to right: Concept cards; Movement cards; Toys and props

Characters:

- 'Roles that children typically look up to or are familiar with: i.e., royalty, scientist, monsters, fairies, etc.' (P1)
- 'Characters need to be interesting (have unique features, goals, hobbies).' (P8)

Magic and Myths, Character Role-Play:

- 'The story needs to excite children, based on fantasy.' (P2)

Goals:

- 'Make children believe they are doing something with a goal in mind.' (P4)
- 'There should be a clear goal to the child's actions.' (P8)

Encouragement and Supportive Feedback:

- 'Encouraging phrases (You got this! Good job!)' (P4)
- 'Cheer the child during the activity.' (P7)
- 'The agent should encourage the children to move in any way they know.' (P8)
- 'The agent should always be supportive and not too harsh.' (P11)
- 'Always follow up with compliments after a problem is solved.' (P11)

Physical Challenges and Problem-Solving Tasks:

- 'Tasks are doable, but not overly easy.' (P5)
- 'Incorporate ideas that can simplify the task if they are too complicated.' (P9)

Obstacles:

- 'Increase the difficulty after every activity.' (P7)

Collaboration and Teamwork:

- 'Either agent acts like or creates a companion for children.' (P5)

Step-by-step Instructions:

- 'Keep the directives short!' (P11)

C.6 Appendix C.6 - Story Patterns

The final results of the thematic analysis, including the main themes, the selected codes under each theme, general patterns, and their application within the story fragments, can be seen below.

Characters:

- Selected Codes: Animals, Humans, and Other Creatures
- Pattern: Most of the stories presented a mix of different types of characters, ranging from animals and humans to other

Fig. 7. Story example used during the workshop

fantastical creatures (e.g., a royal horse as a lifelong companion - animal character; guards - human characters; dragons - dangerous creatures).

Magic and Myths:

- Selected Codes: Magical Help, Magic Items
- Pattern: Several stories included 'magical functions' as helping mechanisms, enabling characters to achieve their goals through the use of magical items and beings (e.g., sirens offering help, a wizard giving suggestions, and the use of a magical candy to cover the jungle adventure).

Character Role-Play:

- Selected Codes: Embodied Roleplay, Transformative Actions
- Pattern: Stories involve embodied roleplay, requiring the protagonist to take on different identities. Imitating different animals and creatures is a common form of transformative action (e.g., turning into a frog, pretending to be an explorer, roaring like a lion, crawling like a worm).

Goals:

- Selected Codes: Mission-based Tasks, Escaping, Escape Mechanisms, Exploration
- Pattern: Three common types of missions were identified in the stories: exploration, rescue, and escape (saving the royal horse, escaping the volcano, exploring the cave, exploring the jungle).

Encouragement and Supportive Feedback:

- Selected Codes: Positive Reinforcements, Encouragement, Compliments
- All stories include positive reinforcement and encouraging statements ('Don't worry!', 'Good job!', 'I know you can do it!').

Physical Challenges:

- Selected Codes: Basic Movements, Dexterity, Strength
- Pattern: Stories include basic movements and actions as tasks, often given metaphorical value and contexts (e.g., 'Pretend you are a frog and jump like one!', 'You have to run as fast as a speeding car!').

Problem-solving tasks:

- Selected Codes: Imaginative Thinking, Puzzles
- Pattern: Several problem-solving tasks were identified that facilitate creative thinking (e.g., finding a way to distract the guards, unlocking a treasure by entering a date).

Obstacles:

- Selected Codes: Adversary fights, Enemies, Human Opposition, Nature-based Challenges
- Pattern: Several stories included fight scenes involving different types of enemies, and nature-based challenges emerged as a recurring pattern within the stories (e.g., fighting a sandworm, fighting a dragon, fighting lava creatures, rising waters, increasing lava levels, growing vines).

Collaboration and Teamwork:

- Selected Codes: Friends/ Companions
- Pattern: All the stories involved a story companion who supported the character (e.g., Barty - the jungle explorer; Amigo - the friend; Jason - the knight).

Step-by-step Instructions:

- Selected Codes: Sequenced Actions
- Patterns: Fast-paced, multi-step sequences were a recurring pattern in several stories (e.g., jumping, crawling, hiding; move forward, and stop, move left and forward, wait, move right).

Environment:

- Selected Codes: Fantasy/ Imaginary Worlds, Adventure Locations
- Patterns: Several stories featured a mix of different environmental settings and worlds (e.g., transitioning from the science lab to the Jurassic World, then to the Wild West, and into the future).

Recurring Concepts:

- Selected Codes: Treasure Adventures, Castle Quests
- Pattern: Stories often share narrative concepts in their plotlines. Treasure hunts or castle quests are the most common ones.

Settings Patterns:

- Selected Codes: Castle, Jungle
- Pattern: Stories often shared similar environmental settings within their plotlines. Castles and jungles represent common environmental settings.

Characters Patterns:

- Selected Codes: Repeated Characters
- Pattern: Several character types, including animals, humans, and fantastical creatures, were recurrent across stories (e.g., horses, monkeys, knights, dragons).

Actions Patterns:

- Selected Codes: Repeated Actions
- Patterns: Certain movements and actions were repeated across several stories. The most recurrent actions were jumping, swimming, running, crawling, and dancing.

Items Patterns:

- Selected Codes: Repeated Items
- Patterns: Certain objects and items were identified multiple times in different stories (e.g., treasure, rocks, and gems).

C.7 Appendix C.7 - The Final Storyline

The final version of the full story can be seen below:

'**(Introduction)** Hello, my friend! It's so nice to see you again! You and your best friend, Nano, are astronaut scientists exploring the Moon. You flew here in a super-fast spaceship - so fast it can travel through space like a shooting star! But something unexpected happened, and your initial mission has to wait! During the exploration, Nano discovered a secret message about the most hunted treasure in the galaxy. But, oh no! Because Nano found the secret information, Jobbo - the galaxy monster - appeared through a time-travel portal and captured him! Nano is frightened and absolutely terrified! But guess what? While jumping through the portal, the monster dropped his treasure map! Your mission is to rescue your dear friend, and the only way to do it is by following the treasure map. But be careful - don't lose the map on your adventure! After each mission you complete, you will earn a magic gem. You have to place it on the map to unlock new steps that lead you closer to Nano. You will travel to amazing new worlds, make new friends, and meet some tricky creatures! But don't worry, you are not alone! I will be right here to help you find your friend! Get the map, leave the spaceship behind, and get ready for your first mission!

(Challenge 1: Jumping through the Portal) First, jump through the portal! Jump, jump, jump, as high as you can, like you're trying to reach the stars! Jump, jump! **(active music starts playing)**

(Challenge 2: Dance with Barty) Wow - great job! You've been teleported into the biggest jungle in the world! Look around… giant trees stretch way up into the sky. Twisty green vines hang down, gently moving in the soft jungle wind. Bright flowers bloom all around you, shining in all kinds of colors, just like a rainbow. Suddenly, your spacesuit is gone… you've become the bravest jungle explorer ever! Look over there! Your jungle explorer friend, Barty, is here too! Dance with him! **(active music starts playing)**

(Challenge 3: Removing the Vines) It's time to get your first gem by exploring the jungle! Oh no … it looks like the vines have grown so big that they are blocking your path. Swing your arms like a jungle hero, together with Barty! Swing, swing, swing your arms! But shhh … don't make too much noise! There are sleepy animals around trying to rest. Don't wake them up! Shhhh… . I believe in you, keep going! Swing your arms, you are almost there! **(active music starts playing)**

(Challenge 4: Collecting 10 Bananas) That was amazing, explorer! Your power to clear the vines is incredible! Now you are deep in the jungle. But wait, look around…. Where is Barty? Barty, where are you? Look up! Monkeys are jumping from tree to tree! Oh, no! They have taken your friend, Barty! Unbelievable, what a twist in your adventure! But wait - the monkey king, Mojo, says you have to climb up the trees and jump from branch to branch to collect 10 bananas. He will release Barty in exchange for the bananas. Climb the trees! Jump, jump, really high! Collect the bananas by stretching your arms and jumping from tree to tree! Come on, you've got 9 bananas! Just one more! Jump! Jump high and stretch your hands one last time! **(active music starts playing)**

(Challenge 5: Save Barty from the Monkeys) Well done! You did a fantastic job! In exchange for the bananas, the monkeys dropped Barty from the trees! He tumbled down, right into some bushes! But don't worry, he is safe! You have to crawl through the bushes like a sneaky jungle creature to find him. Let's go! Get low and crawl! Crawl, crawl, until you find your friend! Crawl, crawl again! **(active music starts playing)**

(Challenge 6: Collecting the First Gem) Impressive, you found him! Barty and I are so happy to have such a brave explorer like you in our team! You've been through so many adventures! You know the jungle like the back of your hand now! Look, you've earned your first gem! Pick it up, grab your map, and place it on the very first *X* spot. Come on, you've got this! The gem is not that heavy, and you are strong enough to carry it! **(active music starts playing)**

(Challenge 7: Getting through the Sand Dunes) There you go! The next step in finding the galaxy monster is unlocked! Fantastic work, explorer! Now let's keep going and collect more gems together! The next gem is a little harder to earn… but I believe in you! The travel portal can be tricky sometimes. This time, it dropped you in the middle of a sandy desert. Wow… It's so hard to get through the sand dunes! Try walking by lifting your knees up! Come on, come on, you can beat the sand! Just a few more steps! **(active music starts playing)**

(Challenge 8: Fighting the Sandworm) Oh, no! You lost your balance, and the wind blew your map away! Look! A sandworm took your map! You need to get it back to finish your mission. Take out your magic sword and get ready to fight the sandworm! Slash, slash, stab! Slash, slash, stab again! **(active music starts playing)**

(Challenge 9: Collecting the Second Gem) What great fighting moves, Captain Dune! Good job! You scared the sandworm away and recovered the map! You didn't give up, and look how far you've come! The second gem is ready to be collected! Pick it up, and place it on the second *X* on your map! **(active music starts playing)**

(Challenge 10: Distracting the Galactic Guards) Amazing effort! Now that you've collected all the gems, the map has led you to the Galactic Castle. The galaxy monster is keeping your friend Nano locked away inside. But oh, no! The galactic guards are protecting the only hallway that leads to him! Quick! Grab the magic rocks next to you and throw them in the other direction to distract the guards. Get the rocks, throw them away! Get the rocks, throw them away! Great job! Now run, run, run as fast as you can to reach Nano! Keep running! **(active music starts playing)**

(Challenge 11: Getting the Treasure) Amazing job, comrade! You found Nano and escaped the castle together like two brave

galaxy knights, leaving the galaxy monster behind! You both jumped through the time-travel portal, and with all the gems placed on the map, it teleported you to the treasure's location: an underwater city. The treasure waits inside a mysterious temple. But, oh, no! There are traps set out in the temple's hallway! You can't just swim straight through the treasure room! To get there, you have to use Nano's secret information. He says you have to move slowly and in a specific pattern. Ready? Let's go! Move two steps forward… and stop! Move two steps forward… and stop! Nice work! Now, move left… and two steps forward! Move left… and two steps forward! Great job! Finally, move right… and two steps forward! Move right… and two steps forward! **(active music starts playing)**

(Challenge 12: Getting Back to the Spaceship) Fantastic work, you are truly unstoppable! These steps have led you to the treasure. You did it, my friends! You found the most wanted treasure of all time! But how will you get back to your spaceship now? Oh, look over there! A magical teleporting flower is blooming next to you. Dance around it, and it will teleport you back to your spaceship. Dance, dance, dance, my adventures! Dance, dance! Your dance moves are out of the charts! **(active music starts playing)**

(Challenge 13: Dance with the Moon Creatures) Finally, you are back on your spaceship, ready to continue your mission to explore the Moon. But before that… It's time to enjoy and celebrate your victory! All the moon creatures have heard about your success. They have prepared a huge party just for you! Dance again with them! Dance, dance! **(active music starts playing)**

(Ending) As for me… my journey with you comes to an end. We've been through so much together on this mission to save Nano from the galaxy monster! Now it's time to say goodbye… for now. Enjoy your party with the Moon Creatures, but do not forget: who knows what amazing missions the future holds? See you next time, my brave friend!'

C.8 Appendix C.8 - Application of the Proppian Functions

The selected Proppian functions, along with their application in the final story, are highlighted below:

Absentation:

- Description: One of the members of a family absents himself from home.
- Application in the story: Nano, the protagonist's friend, goes missing. Because he possesses valuable information about a hidden treasure, he is captured by Jobbo, the galaxy monster.
- Narrative Excerpt: 'Because Nano found the secret information, Jobbo - the galaxy monster - appeared through a time-travel portal and captured him!'

Interdiction:

- Description: An interdiction is addressed to the hero.
- Application in the story: Since the only way to find his friend is by using the monster's map, the protagonist must not lose it.
- Narrative Excerpt: 'But be careful - don't lose the map on your adventure!'

Villainy:

- Description: The villain causes harm or injury to a member of a family.
- Application in the story: Jobbo, the galaxy monster, captured Nano, leaving him scared and overwhelmed.
- Narrative Excerpt: 'Nano is frightened and absolutely terrified!'

Departure:

- Description: The hero leaves home.
- Application in the story: The protagonist must abandon his initial mission of exploring the Moon's surface, leave the spaceship behind, and begin the journey to find his dear friend.
- Narrative Excerpt: 'Get the map, leave the spaceship behind, and get ready for your first mission!'

Violation:

- Description: The interdiction is violated.
- Application in the story: The interdiction not to lose the map is violated when the sandworm takes it from the protagonist.
- Narrative Excerpt: 'Oh, no! You lost your balance, and the wind blew your map away! Look! A sandworm took your map! You need to get it back to finish your mission.'

Struggle:

- Description: The hero and the villain join in direct combat.
- Application in the story: The protagonist's struggles are illustrated through a series of challenges encountered along the journey, such as clearing the vines in the jungle, saving Barty from the monkeys, fighting the sandworm to recover the map, avoiding the galactic guards to rescue Nino, and avoiding the traps in the temple to reach the treasure.
- Narrative Excerpt: 'Oh no … it looks like the vines have grown so big that they are blocking your path.'
- Narrative Excerpt: 'Monkeys are jumping from tree to tree! Oh, no! They have taken your friend, Barty! Unbelievable, what a twist in your adventure!'
- Narrative Excerpt: 'A sandworm took your map! You need to get it back to finish your mission.'
- Narrative Excerpt: 'But oh, no! The galactic guards are protecting the only hallway that leads to him!'
- Narrative Excerpt: 'There are traps set out in the temple's hallway! You can't just swim straight through the treasure room!'

Transfiguration:

- Description: The hero is given a new appearance.
- Application in the story: Throughout this mission, the protagonist ends up in different worlds where he adopts new identities, such as a jungle explorer, a desert captain, or a brave galaxy knight.
- Narrative Excerpt: 'Suddenly, your spacesuit is gone… you've become the bravest jungle explorer ever!'
- Narrative Excerpt: 'What great fighting moves, Captain Dune!'
- Narrative Excerpt: 'You found Nano and escaped the castle together like two brave galaxy knights.'

Victory:

- Description: The villain is defeated.

- Application in the story: The protagonist escapes from the castle with his friend Nano, leaving the galaxy monster behind, without the secret information to the treasure.
- Narrative Excerpt: 'You found Nano and escaped the castle together like two brave galaxy knights, leaving the galaxy monster behind!'

Returns:

- Description: The hero returns.
- Application in the story: Afer completing the mission, the protagonist returns to the spaceship by dancing around a magical teleporting flower.
- Narrative Excerpt: 'But how will you get back to your spaceship now? Oh, look over there! A teleporting flower is blooming next to you. Dance around it, and it will teleport you back to your spaceship.'
- Narrative Excerpt: 'Finally, you are back on your spaceship, ready to continue your mission to explore the Moon.'

Solution:

- Description: The task is resolved.
- Application in the story: After overcoming all the challenges encountered along the way, the protagonist rescues his friend Nano. As a reward for his earlier loss, he finds the most wanted treasure with Nano's help.
- Narrative Excerpt: 'You found Nano and escaped the castle together like two brave galaxy knights, leaving the galaxy monster behind!'
- Narrative Excerpt: 'These steps have led you to the treasure. You did it, my friends! You found the most wanted treasure of all time!'

Recognised:

- Description: The hero is recognised.
- Application in the story: The protagonist's achievement is celebrated by all the Moon Creatures, who throw a fun party to celebrate his success.
- Narrative Excerpt: 'It's time to enjoy and celebrate your victory! All the moon creatures have heard about your success. They have prepared a huge party just for you!'

D APPENDIX D - EVALUATION PHASE

This section provides more details about the evaluation phase of the prototype.

D.1 Appendix D.1 - Observational Sheet

An example of a completed observational sheet for one story fragment can be seen in Figure 8.

D.2 Appendix D.2 - Interview Questions and Answers

The interview questions and their corresponding answers are presented below. The answers were initially given in Dutch and subsequently translated into English.

Question 1: What did you think of the story or content of the agent?

Answers:

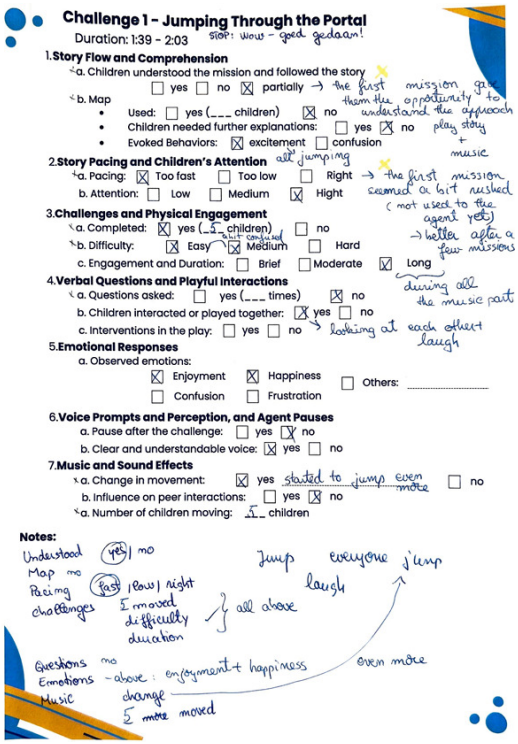

Fig. 8. Example of a completed observational sheet

- 'Ah, okay. Yeah, the story. It was really fun, just sometimes difficult words for the younger children, for the younger four/five-year-olds. Portal – what is that?'
- 'They don't know that word, but the story itself and the voice telling it – that was really fun.'
- 'Sure, but for the four-year-olds: they don't know what a portal is or that you go to another jungle, that you're being transported. That's still difficult for the four and five-year-olds, but the older children can understand that. Yeah, otherwise really fun. Yeah, yeah.'

Question 2: What did you think of the physical challenges?

Answers:

- 'The movement. Yeah, fun, fun, a lot: enthusiastic, crawling, climbing, jumping – yeah, fun. Yeah, yeah, yeah.'

Question 3: What did you think of the voice of the agent and the music or sound?

Answers:

- 'Also good.'
- 'Yeah, no, it was really fun.'

Question 4: Do you see this type of technology being integrated into kindergartens? If so, what guidelines or considerations would you suggest for doing so?

Answers:

- 'The music or the sound, the story – just like if it were in an animal that talks. Now it's standing behind it. Then I think it's more fun for children if it becomes more real. So, that you

have it in something you can see standing there, what it is – a bear or an astronaut. Then it becomes more alive for them.'
- 'Yeah, well, now you've put it behind something. Kids then see it as like oh, that's an animal, but that doesn't really matter. But for a kindergarten, like here, it's easier if it's built into something, and it lasts longer.'

Question 5: What would you add to this technology?
Answers:

- 'Yeah, it works well, it's already really good. No, nothing.'

Question 6: What would you remove or change?
Answers:

- 'Well, the difficult words. Yeah, the difficult words. Yeah, and the stories are exciting enough for all ages.'

Question 7: What did you like the most about this experience?
Answers:

- 'Uh, them being active, jumping, crawling. Yeah, so movement with it, and also listening in between. Yeah, and then the little stones they earn. Yeah, no, really fun.'
- 'The moving, the jumping.'

Question 8: What did you not like, or what did you find too confusing or hard?
Answers:

- 'And not fun were the difficult words. Well, not fun (not necessarily), but it's not meant for the younger age groups.'

Question 9: Was the story the right length, or did it feel too long or too short?
Answers:

- 'Yeah, it could be longer. Yeah, definitely longer. Yeah, it can be a bit longer because they liked it enough, they wanted more. And they love repetition. So you could do it again. Often, if you do it ten times, they'll still enjoy it. Yeah, kids love that. So yeah, I think you can keep this and then just do it again. More of that.'

Question 10: Do you think it is easy to use this technology in kindergartens, and would it be a nice tool for you to have?
Answers:

- 'Yeah, to have alongside other things. But also outside – you can do it in a fun way, right? Like in the forest or… You can make it seem more real and make it bigger and have them move more through the space and such. More like that. I think that's definitely possible. But also for toddlers, 3 and 4-year-olds. That you can also make a fun story for them.'

Question 11: Do you think you should be there while they are playing?
Answers:

- 'Yeah, as... as a game, as part of... doing it as a game. Yeah, but then together, with you helping too. Yeah, just do it together. That's more fun, because then they'll enjoy the game more. And they'll participate more enthusiastically.'
- 'Otherwise they're standing there like (what should I do). And then playing around is more fun together.'

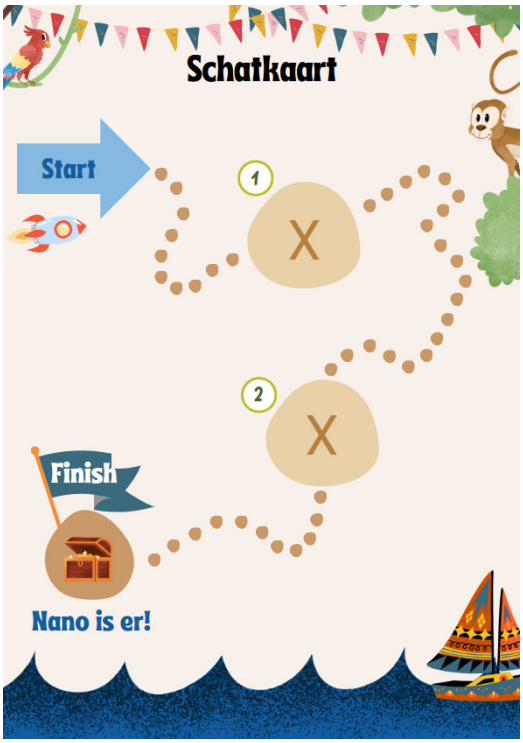

Fig. 9. Map distributed to children

D.3 Appendix D.3 - Map

The map distributed to children during the testing session is shown in Figure 9.

D.4 Appendix D.4 - Testing Analysis

Insights from the observational sheets, open-ended question responses, and interview were clustered based on the following validation metrics: *Content and Story Narration*, *Physical Engagement and Impact on Children*, and *Agent's Performance and Usability*. Figures 10, 11, and 12 illustrate the resulting sticky notes corresponding to each cluster.

Fig. 10. Cluster 1: About the content and the story narration

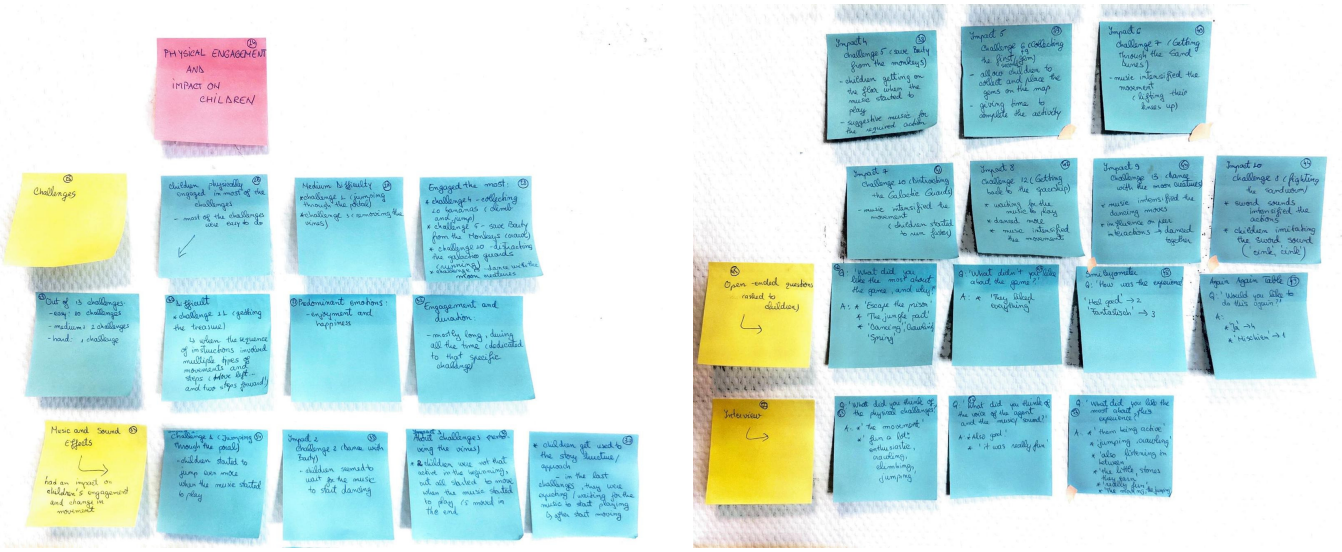

Fig. 11. Cluster 2: About the physical engagement and the impact on children

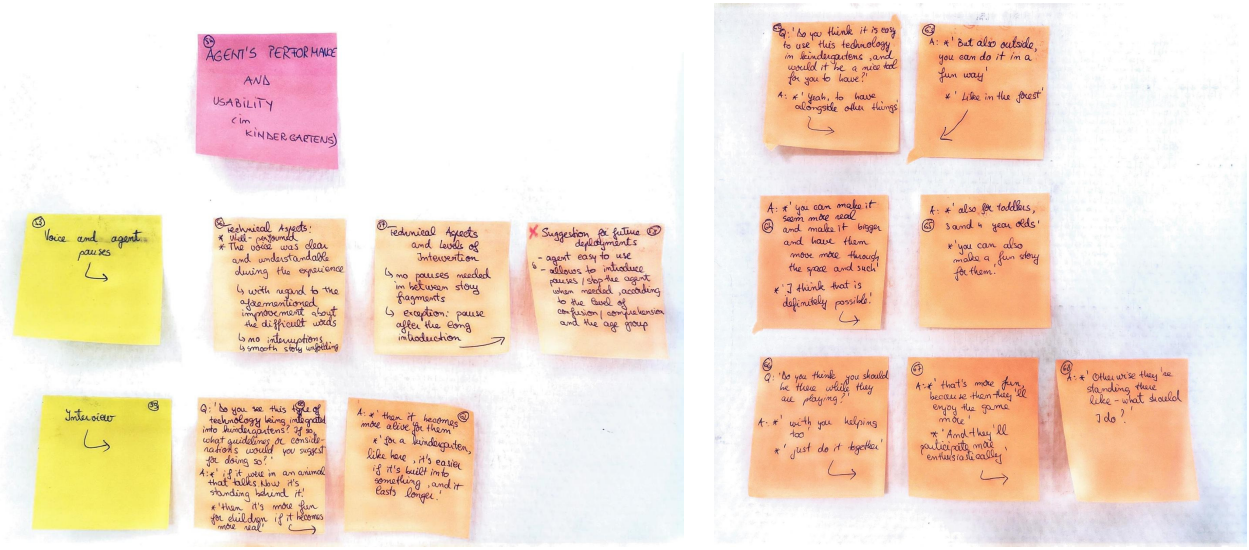

Fig. 12. Cluster 3: About the agent's performance and usability