Inclusive'R'Stories: An Inclusive Storytelling Activity with an Emotional Robot

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***Abstract*—Storytelling has the potential to be an inclusive and collaborative activity. However, it is unclear how interactive storytelling systems can support such activities, particularly when considering mixed-visual ability children. In this paper, we present an interactive multisensory storytelling system and explore the extent to which an emotional robot can be used to support inclusive experiences. We investigate the effect of the robot's emotional behavior on the joint storytelling process, resulting narratives, and collaboration dynamics. Results show that when children co-create stories with a robot that exhibits emotional behaviors, they include more emotive elements in their stories and explicitly accept more ideas from their peers. We contribute with a multisensory environment that enables children with visual impairments to engage in joint storytelling activities with their peers and analyze the effect of a robot's emotional behaviors on an inclusive storytelling experience.**

***Index Terms*—Storytelling, Inclusion, Child-Robot Interaction**

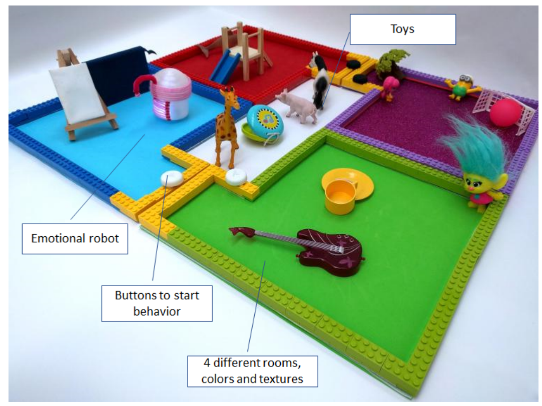

Fig. 1. Inclusive'R'Stories prototype

I. Introduction

Storytelling is a powerful tool for communication, collaboration, and creativity [24], [46]. Prior research on interactive storytelling systems has shown benefits in supporting the development of language, social, and cognitive skills [24]. Nowadays, there is a wide range of interaction options, depending on whether children want to listen to stories, interact with them, or tell their own stories.

Many research approaches have favored free expression and creativity by engaging children as story authors. Particularly, multisensory environments composed of physical spaces and familiar toys have been previously proposed to support children in the storytelling process [2], [11], [12]. Interactive robots have also been employed to aid in storytelling [6], [19]. These tangible approaches to storytelling provide novel opportunities to foster collaborative work and playful partnerships [17], [20], [58], enabling children to co-create stories, make sense of their world, and practice social skills.

However, despite the numerous benefits of (collaborative) storytelling, research has largely ignored groups of children with diverse sensory abilities. Children living with visual impairments (VI) are increasingly educated in mainstream rather than special schools [54]. However, despite being included in the same classrooms as their sighted peers, studies highlight reduced opportunities for collaborative learning and potential for isolation [40], [44]. These issues have been partially attributed to existing technologies, which tend to prioritize accessibility over inclusion; they are designed to be used by children living with VI alone and not by their sighted peers.

Interactive storytelling activities could reduce barriers to inclusion. For instance, multisensory environments and interactive robots can provide multimodal feedback, opening novel opportunities for inclusive storytelling where children with and without VI can share technology [38], [43], [71]. However, this potential remains largely untapped.

In this paper, we explore the extent to which off-the-shelf robotic devices can be used to support inclusive storytelling experiences. Besides their tangibility, robots are able to express emotions, which have been shown to help children build their emotional intelligence skills, namely in perceiving and expressing emotional states [30]. Emotionally expressive robots have also been shown to foster play and learning [8], [61] but are less explored in collaborative storytelling activities. In this work, we aim to answer three main research questions: (1) are multisensory environments and robotic devices effective in supporting inclusive storytelling experiences? (2) how do the robot's emotional behaviors affect the content of the story? (3) what strategies, roles, and behaviors do children adopt in mixed-visual ability storytelling activities?

To answer these questions, we developed an interactive multisensory workspace (Fig. 1), that houses characters and other objects as well as a robotic device. Children were free to play with numerous familiar objects and interact with the robot in a collaborative storytelling activity. To evaluate the effects of emotional expression, we conducted a within-subjects study where mixed-visual ability dyads were asked to co-create an original story. We analyzed children's storytelling process, collaboration dynamics and created stories. Results show that children portrayed more empathetic behaviors when creating a story with an emotional robot by including more emotive elements in their stories and explicitly accepting more ideas from peers. Generally, the inclusiveness of storytelling experiences can be fostered by both a multisensory environment and a robot displaying multimodal emotional behaviors.

The key contributions of this paper are: first, empirical results on the effects of emotional behaviors on a mixed-visual ability storytelling experience; second, we describe emergent collaboration behaviors when VI and sighted children engage in joint storytelling activities; third, we describe the design and development of Inclusive'R'Stories, a multisensory system that allows mixed-visual ability children to engage in collaborative storytelling activities. These contributions are relevant to accessibility researchers and designers of robotic technologies, as they provide the basis for designing systems that support inclusive storytelling for mixed-visual ability children.

II. Related Work

We first discuss related work on interactive storytelling and how computer technologies have been used to support collaborative storytelling. Then, we discuss research that attributes emotional expression to robotic devices through various sensory modalities. Finally, we present previous attempts to create robot technologies to support people with VI.

A. Interactive Storytelling

Children develop social skills, creativity, and emotional regulation in storytelling activities [14], [24], [26], [57], [60]. Prior work on interactive storytelling has explored a variety of interactive solutions such as digital, sound-based, and tangibles [6], [13], [23], [56], [75], enabling the creation of multisensory environments [2], [7], [11], [12], [58]. In creative storytelling activities, children often manipulate drawings, images, sound, objects and combine them to create a narrative in time and space [11], [17], [50]. For instance, toys, interactive objects, and robots have been used to support the creation of stories by children through pre-recorded story segments [33], [67], [76].

Robots are particularly interesting in storytelling activities due to their embodiment and ability to express emotions. For instance, they can be used in role-play activities in emotionally charged domains (e.g., bullying). The use of emotions in robots has shown to be effective in multiple applications, including therapy [48], [61], playful [3], [41], and learning environments [22], [29]. Emotional robots in storytelling activities are also widely explored [29], [30]; however, the effect of the robot's emotions on children's creative process is less clear.

Storytelling systems can support co-creation and collaboration between children using shared physical objects [17]. As children engage in play, they collaboratively build scenarios, narrate stories, enact characters and create new ideas. The activity creates a safe and engaging place for children to share feelings and learn individual and social skills [24]. Nevertheless, collaborative storytelling platforms are mainly designed for sighted children [17], [20], [58]. Despite its potential to be used as an inclusive activity, interactive storytelling solutions that support mixed-visual ability settings are scarce [16], [68].

B. Emotional Expression in Robots

Social robots are embodied agents that interact with humans at a social level. Therefore, social robots need to communicate naturally with people using both verbal and non-verbal signals. Additionally, those interactions must be able to adapt to the appropriate level of abstraction according to the context [59]. Humans use emotions to display their internal states and expectations; thus, robots should perceive and convey emotions to be believable [10], [42], [51], [53], [59], [73]. Emotional robots are finding increasing applications in different settings [77]. They can be used to foster play, learning and influence affective responses in therapy [8], [61], leisure [4], [15], [31], and education settings [29]–[32].

Previous work has replicated human-like manners of conveying emotion in robots through gaze behaviors, gestures, and facial expressions [5], [59], [63], [77]. However, these approaches may not apply to non-anthropomorphic robots (e.g., object-shaped robots). In such cases, robots express emotions differently, using sound [34], [35], [51], [78], colors and lights [64], [65], haptics [27], [65], and movement [62].

In mixed-visual ability groups, auditory feedback has great potential as an accessible interaction modality. HRI researchers usually use Non-linguistic Utterances consisting of beeps and squeaks to convey emotions (e.g., R2D2 or WALL-E's sounds) [28], [51], [52], [78]. Others have started to explore sound beyond the robot by including it in the environment, making it more immersive and engaging [35], which can be of particular interest in activities for people with VI [36].

Prior research explored the multimodal emotional expression in robots by combining color, motion, vibration, and sound [34], [65]. Results show that happiness is better perceived using color-motion combinations, blinking pink, yellow or green lights and dance-like movements. Sadness is associated with a falling beep and slow motions, and fear is better perceived by hiding or escape-like motions. A red light is associated with anger, particularly when combined with an increasingly louder sound and intense vibration. However, previous studies were conducted with sighted people, and results may have differed with people with VI. We extend previous work by leveraging current recommendations for emotional expression in robots and focusing on a new interaction context, collaborative storytelling with mixed-visual ability children.

C. Robot Technologies for Visual Impairment

Prior research explored robots as assistive technologies to support people with VI in everyday activities, such as navigation [1], [45], [69], color-recognition [49], and manual activities [9]. Robots have also been shown to be effective in supporting spatial learning for children with VI [18], [72]. Beyond their utilitarian capabilities, robots have been used as social enablers, leveraging their ability to express and perceive emotions while sustaining social relationships [21].

In mixed-visual ability contexts, robots have been used to help children learn computational thinking concepts [47], [55], [70], [72] or as inclusive playful tools [39], [43]. They enable a more inclusive environment by enriching children's perception of the activities, goals, and surroundings, allowing access, participation, and self-expression in group activities. In this work, we explored the extent to which a mainstream robotic device could be combined with a multisensory workspace to foster co-creation activities. Moreover, we build on existing literature of leveraging off-the-shelf robots that are not designed with accessibility in mind to develop an interactive storytelling prototype that supports inclusive experiences.

III. Design of Inclusive'R'Stories

We built Inclusive'R'Stories, an accessible and inclusive interactive prototype that can be used by mixed-visual ability children aged between 6 and 10 years old to co-create stories. Inclusive'R'Stories is composed of a multisensory workspace, everyday toys, and an Ozobot Evo robot. The prototype aims to explore the effect of the robot's emotional behavior, particularly the expression of four basic emotions: fear, anger, happiness, and sadness.

The design of Inclusive'R'Stories heavily relies on multisensory feedback: tactile, auditory, and visual feedback, as it must engage VI and sighted children alike. To this end, we engaged in an iterative design process with a focus group composed of two psychologists, a special needs teacher, a speech therapist, an ophthalmologist, five educators (one is blind), and one parent. We were interested in exploring the spatial layout of the workspace, its multisensory feedback, and the robot's emotional behavior.

A. Multisensory Workspace and Robot Interaction

One of the main sources of tactile feedback is the prototype's workspace. As seen in Figure 1, we divide the workspace into four small rooms to encourage exploration, particularly by children with VI. Rather than focusing on a single environment, we leveraged multiple rooms to support a variety of stimuli and foster creativity. The workspace was built using LEGO blocks as children often play with these toys, which also provide tactile feedback.

In each room, the robot displays one specific scripted emotional behavior. Moreover, each room is represented by a unique color that matches the emotional behavior of the robot [25], [34]: green - happiness, red - anger, blue - sadness, purple - fear. Besides having different colors, each room has a uniquely textured floor (EVA foam, felt, glitter EVA foam, cardboard) to facilitate their identification via tactile cues.

Regarding auditory feedback, we added environmental sounds to each room. Our goal is to create a more engaging experience during storytelling activities while promoting creative thinking by providing a new source of information [35]. Children are faced with the self-imposed challenge of guessing what the sound represents and may choose to integrate it into their narratives. Each room has a unique environmental sound representing typical places in schools, such as a music classroom, playground, cafeteria, and library. This design choice was suggested by a psychologist and aimed at enabling children to vent about personal and lived experiences in those environments. Each sound lasted approximately nine seconds.

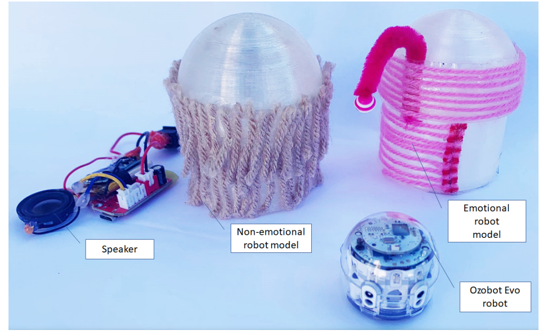

Fig. 2. Robot and components used in the study.

We used a 'door bell' metaphor to trigger the rooms' environmental sound. Each room has an off-the-shelf Bluetooth button[1] that, once pressed, triggers the sound and the robot's behavior. These buttons are the core of the prototype's interactivity, and children can press them as many times as they want. Each button is stuck with velcro on the room's protrusion, which symbolically represents the room entrance.

Complementary to the multisensory workspace, Inclusive'R'Stories also includes everyday toys that can be used as characters or decorative objects during the co-creation activity. These are intended to spur creativity and support playfulness.

Regarding the robot, we used an Ozobot Evo augmented with a 3D printed model and additional decorations (Figure 2). The model encapsulates the robot and provides additional tactile and visual feedback. Moreover, it provides a non-anthropomorphic shape that symbolizes an imaginary creature.

B. Robot's Emotional Behavior

The robot's emotional behavior combines visual, auditory, and tactile feedback. The visual feedback takes the form of the robot's lights' color and cadence, while the tactile component takes the form of movement variations depending on its speed and range of motion. It is noteworthy that children with VI (e.g., low vision) might still perceive visual feedback. We followed the guidelines reviewed in Section II-B to create the emotional expression of the robot. Moreover, all design decisions were validated by our focus group.

Regarding the auditory feedback, we draw inspiration from Jee et al. [28], which used Wall-E sounds to express emotions. Our robot uses familiar sounds from the movie "Despicable Me", particularly Minion characters' sounds, to express the four basic emotions. Each emotional behavior lasts approximately nineteen seconds.

The happy expression is embedded in green lights flashing at a fast and active pace while the robot moves in a quick and fluid zigzag movement that can be perceived as the robot dancing. The sound of minions laughing is continuously played during the entire expression.

[1] https://flic.io/

Regarding the anger behavior, we use assertive intermittent red lights and repeated motions composed of a fast forward movement followed by an even faster backward movement. These motions can be perceived as the robot trying to hit something, reassessing and retreating. These motions are accompanied by a grunting sound when the robot moves forward.

In turn, the sad behavior is a composition of blue lights that blink very slowly alongside prolonged and intermittent movements, almost as if the robot is slowly walking and stopping. The sound of minions crying accompanies the movement.

Lastly, the fear behavior uses purple lights in two of the five available LEDs while the others are turned off. The active LEDs blink slowly while the robot gently moves in a slow movement forward as if it was afraid of facing something, followed by a sudden faster backward movement, which can be perceived as if it was running away in fear.

C. Hardware and Software

We use an Ozobot Evo robot that can move on a flat surface. One of the main reasons to choose an Ozobot was its small size and robustness; we wanted children to manipulate it as a toy. The robot is controlled via Bluetooth. Due to the low volume of the robot's internal speaker, we built a small Bluetooth speaker that is encapsulated in a 3D printed model (Figure 2). We rely on a computer to connect the Bluetooth buttons, speaker, and robot. The communication is achieved using a Bluetooth library - Bleak - while the auditory output is controlled via a python library - SimpleAudio. Once a Bluetooth button is pressed, it triggers a script playing the respective environmental sound and pre-programmed behavior.

IV. User Study

We investigate how Inclusive'R'Stories can support inclusive storytelling experiences in mixed-visual ability groups. Moreover, to assess the effect of the robot's emotional behavior in the story authoring process, we conducted a within-subjects study with two conditions: experimental condition - robot displays emotional behaviors; and control condition - the robot is turned off, functioning as any other toy.

A. Participants

The research protocol was approved by the *Instituto Superior Técnico*'s Ethics Committee, and parents/tutors signed consent forms. We evaluated the prototype in two mainstream schools with a total of 16 children, which participated in mixed-visual ability dyads. Each dyad was composed of two befriended children to ease communication. Children's average age was 8.75 years old. Teachers informed us of children's visual acuity based on a professional diagnosis, which was classified in 4 levels [66]: 0 mild, 3 moderate ((Children 1 - C1, Group 1 - G1), (C9,G5), (C15,G8)), 3 severe ((C3, G2), (C11, G6), (C13, G7)), and 2 blindness ((C5,G3), (C7,G4)).

B. Apparatus

We used the Inclusive'R'Stories prototype and video recording equipment. Regarding the robot's 3D model, we followed the strategy used in [74] and created two versions, one for each condition. As seen in Figure 2, they are distinguishable by their colors and tactile characteristics so that children with and without VI could easily differentiate between them. Additionally, these models were introduced as distinct characters to minimize children's expectations regarding the different robot's behaviors. We used the neutral-colored 3D model in the control condition and the pink one in the experimental condition as this can be perceived as more active or alive.

The workspace's environmental sounds were counterbalanced between conditions to lessen the learning effects. Thus we had a total of eight different environmental sounds: classroom (purple room), playground (blue room), soccer field (red room), music classroom (green room), library (purple room), cafeteria (blue room), gym (red room) and art classroom (green room). The first four were used in the first session, while the last four were used in the second session, regardless of the tested condition. Additionally, we used 23 everyday small toys related to the environments described above.

C. Procedure

Considering the restrictions in recruiting children with VI, we conducted a within-subjects study. Therefore each dyad tested our two conditions in counterbalanced order. To mitigate learning effects, we spaced each session by one week. Each session took place in a controlled and quiet room located in the children's school. On average, each session took 25 minutes ($SD = 5.7$). Two researchers were present in all sessions and were responsible for setting up the system and guiding the children throughout the session. Each session was composed of 4 phases. The first phase consisted of introducing children to the system's layout (see Figure 1), so they could get familiar with the four rooms' location and with the toys, which were the same across conditions. We put them outside the rooms, in an isolated region, to ease the exploration process for children with VI. In the second phase, children were handed the robot and instructed to explore it. The third phase was designed as a training to make children comfortable with the storytelling process and with the prototype. In this phase, we asked them to visit one room at a time, and in each, we prompted children to think about the main elements that constitute a story: scenario, characters, and actions. In order to differentiate this phase from the main storytelling activity, we used different environmental sounds that would not be used again and introduced the robot's behaviors (on the experimental condition) in a random order. The last phase consisted of the main storytelling activity, in which the researchers instructed children to work together and create a story with the robot. Additionally, they were told that they could visit each room more than once. This phase lasted, on average, 14 minutes ($SD = 5$).

D. Data Collection and Analysis

All sessions were video and audio recorded. One researcher conducted a thematic analysis of the activity in 3 different areas: inclusive interaction, story content, and collaboration. A second researcher validated the resultant coding scheme.

We included two measures within inclusive interaction: manipulation and robot engagement. Manipulation included the number of times a child picked or put his hand over the robot, while robot engagement encompassed all actions where children were only focused on the robot, which could be done through observation, touch, or by getting closer to it.

In terms of the story content analysis, we used metrics that would take into account the creative and emotional content. Regarding the former, we analyzed three metrics: *fluency*, the number of story segments; *toys*, the number of toys used; and *original interventions*, which can either be the number of original segments(rare story segments in all 16 stories created) or the number of times children used toys with an alternative use. In turn, the emotional content was encompassed in three metrics: *robot emotions*, the number of times children attributed emotions to the robot; *toys emotions*, the number of times children attributed emotions to toys; and *robot emotions (in)congruence*, the number of times the emotion attributed to the robot matched its designed emotional behavior.

Finally, the analysis of collaboration included accessibility issues, exchange of ideas, and children's roles. The two metrics for accessibility issues, inspired by [37], were: *accessibility requests*, which are the number of requests for accessibility support; and *accessibility supplies*, the number of answers to the previous requests. The exchange of ideas had five measures: *requesting ideas*, frequency of a child asking the peer for ideas; *supplying ideas*, number of ideas offered by each child; *contributing ideas*, which counts the contributions made to peer's ideas; *accepting ideas*, the number of times a child explicitly accepted a peer's idea; and *rejecting ideas*, which counts the number of times a child rejected a peer's ideas. Children's roles were coded according to follower, co-creator, logistic supporter, and parallel creator [79].

V. Results

We present qualitative data observed during the data annotation. Regarding the quantitative data, we performed a statistical analysis. According to a Shapiro-Wilk test, our dependent variables are not normally distributed. Therefore, we used the Wilcoxon signed-rank test to compare differences between conditions. The comparisons between sighted and children with VI were achieved with the Mann-Whitney U test.

A. Inclusive Storytelling Experience

To analyze how the robot's behavior affected the interaction in a mixed-visual ability group, we looked at how children engaged with the robot, and how they specifically manipulated it. Additionally, we have also compared the same measures between children with VI and sighted.

Robot's behavior increased manipulation/engagement. We found a significant difference between conditions on the manipulation of the robot ($Z = -1,973, p = 0.049$) and on the engagement with the robot ($Z = -2.240, p = 0.025$). In the experimental condition, children picked and touched the robot more times ($M = 2.563, SD = 5.304$), compared to the control condition ($M = 1.5, SD = 4.017$). Similarly, they engaged more with robot, when it had emotional behavior ($M = 5.625, SD = 7.907$), compared to when it had no behavior ($M = 1.938, SD = 4.155$).

Besides the direct manipulation and interaction with the robot, the high levels of engagement on the experimental condition were also noticeable in children's responses. Children seemed more relaxed on the experimental condition rather than on the control condition, as two groups (G1,G7) even danced when the robot expressed the happy behavior. Similarly, there were also some children (C1,C2,C5,C13) who laughed at the different robot's behaviors while others displayed empathy responses (G7,G3) as they asked the robot, *"Are you sad, Rose?"*. Contrary, this engagement was not so visible in the control condition as the robot was seen more like a normal toy. In two of the sessions (G5,G6), it was even left behind while children continued to create the story only using the other toys.

Children with visual impairment manipulated/engaged more with the emotional robot. When comparing the manipulation and engagement across conditions, the differences were only significant in the experimental condition (Manipulation: $U = 8, p = 0.007$; Engagement: $U = 13.5, p = 0.042$) but not in the control condition (Manipulation: $U = 27, p = 0.441$; Engagement: $U = 21, p = 0.183$). When the robot had emotional behaviors, children with VI manipulated ($M = 4.75, SD = 6.944$) and engaged ($M = 8.75, SD = 8.94$) more with it than sighted children (respectively $M = 0.375, SD = 1.061$; $M = 2.5, SD = 5.632$).

As the robot is dynamic in the experimental condition, children with VI used some strategies to follow its movement and engage with the robot. For instance, four children (C5,C7,C11, C13) occasionally left their hand on top of the robot, while five (C1,C5,C7,C9,C11) moved closer to it and three children (C1,C5,C9) opted by holding the robot to perceive its movement better. Interestingly, children with VI did not interact so autonomously with toys. When they wanted to use them they would prefer to ask their sighted peers to fetch the toy for them(N=13) or ask about its location (N=9).

Children with VI also followed sound, which was richer in the experimental condition. This observation is coherent with prior mixed-visual ability studies [43] where sighted peers engage with robots through visual stimulus while children with VI use tactile and sound as primary signals.

B. Content of the Story

Stories' creativity was similar between conditions. For creativity measures, we did not find a statistically significant difference between conditions on the fluency ($Z = -0.995, p = 0.320$), nor on the total number of used toys ($Z = -0.057, p = 0.954$). Similarly, the difference between the number of story actions that included the robotic character in each condition was also not statistically significant ($Z = -1.895, p = 0.058$). However, the trend on the data suggests that when the robot had emotional behavior, children included it more in their stories ($M = 20.375, SD = 8.031$), compared to when it had no behavior ($M = 12.375, SD = 6.093$).

Although there was no significant difference between conditions regarding creativity, it is relevant to notice that both conditions induced very original contributions. These could take the form of original uses for toys (N= 23), adding sounds (N=6), or original story ideas (N=36). One example of the original use of toys occurred in group G6 when a child asked the peer for an object that could represent a soup, and he chose a pig, thus adding a pig soup to the story. In another example, group G4 created a zoo scenario, and as they wanted to include a zebra, one of the children suggested using the black and white horse. Children also made additional sounds to create context and richer narratives, such as bells (G7), celebratory screams when scoring a goal (G1), dialogues (G1, G6, G7, G8), and even sounds to simulate a bathroom (G6). On the other hand, some examples of original ideas include the integration of a tsunami or earthquake into the story (G1, G3), reusing familiar fairy tales (G6), or enriching a hunted house scenario with a murderer ping (G8). Some original ideas also included the robot's behavior, as one group (G1) invented that the robot's sound would save a dolphin choked with a plastic bottle. Additionally, one group (G6) also integrated into their second session story, the robot from the first one, relating them as cousins - "My cousin Rose, from the last story, (...)".

Robot's behavior increased the story's emotional content attributed to the robot. Regarding the emotional content of the stories created, we found a significant difference in the number of emotions attributed specifically to the robotic character ($Z = -3.317, p = 0.001$). In the experimental condition, in which the robot displayed emotional behaviors, children attributed more emotions to it ($M = 2.690, SD = 2.496$), when compared to the control condition ($M = 0.060, SD = 0.250$). However, no significant difference was found on the emotions attributed to other toys ($Z = -1.653, p = 0.098$).

The robot's emotional behavior sometimes triggered story segments that were explicitly or implicitly based on children's real-life events. For example, when the robot displayed the anger behavior, one child (C3) said that the robot was angry with a friend because she skipped the line. While another group (G7), when faced with the sad behavior, said that the robot was hurt, so it needed to look for the school's nurse as it had already happened to them. That story segment even allowed that group's members to vent with each other about a stressful and similar situation that had happened with one of their peers. In turn, when faced with the fear behavior, one group (G6) suggested that the robot was screaming because it did not like studying, while another group (G4) said that the robot was laughing at a painting done by another character, when they heard the happy behavior.

Emotions (in)congruence was similar between children with visual impairment and sighted. Regarding the emotions attributed to the robot by the children, we divided them into congruent and incongruent according to whether they matched the designed emotion for the robot in that particular moment. We found no significant difference between children with and without VI on using congruent($U = 20, p = 0.185$) or incongruent emotions($U = 21, p = 0.203$), suggesting that children perceived emotional behaviors similarly. The majority (33 occurrences) of emotional story segments created were used to justify the robot's emotional behaviors, while only two were used to modify the robot's emotional state. For example, to justify the fear behavior, one group (G6) stated that the robot was afraid of something terrifying, while upon seeing the angry behavior, another group (G7) said that the robot was angry because it had lost a game. On the contrary, when faced with the sad behavior, one group (G2) created the narrative that the robot was going to the zoo so it could feel better, while another group (G6) decided to offer the robot a soup so it could start being happy, which are narratives that tried to modify the robot's state.

C. *Co-creation of the Story*

We analyzed the collaborative actions between children during the co-creation of the story, which included both accessibility support and exchange of ideas. Additionally, we also analyzed the roles each child played during the activity.

Accessibility requests/supplies were similar between conditions. For collaborative support in accessibility issues, we did not find a significant difference between conditions on accessibility requests ($Z = -1.005, p = 0.315$) nor on accessibility supplies ($Z = -0.157, p = 0.876$).

As expected, the majority of the accessibility requests were made by children with VI, and these included informational requests regarding the location of the toys(N=10) and its description (N=8), requests to help them find a toy, or requests for their peers to fetch them the toy they wanted (N=21).

Robot's behavior increased ideas acceptance. In terms of ideas exchange, we also did not find a significant difference between conditions on the number of supplied ideas ($Z = -1.242, p = 0.214$), requested ideas ($Z = -1.414, p = 0.157$), nor on the contributions to peers' ideas ($Z = -0.063, p = 0.950$). Interestingly, the number of times a child explicitly accepts his peer's ideas was significantly different between conditions ($Z = -2.126, p = 0.034$). Specifically, it was higher when the robot had emotional behaviors ($M = 3.06, SD = 2.886$), compared to the control condition ($M = 1.690, SD = 2.152$). Contrarily, there was no significant difference between conditions on the number of peers' ideas explicitly rejected ($Z = -0.498, p = 0.618$).

Children could participate in the story creation process through various actions. They could either suggest a story segment (N=413) or propose the usage of a particular toy (N=252), as they could also complement the peer's idea (N=95) by placing a toy related to that idea or offering details to enrich this. Children could also share their opinion regarding the robot's behavior or the environmental sound, which would sometimes lead to negotiations (N=4) until a final consensus was attained or a parallel segment was created (N=6).

Based on these interventions, children could have several roles throughout the storytelling activity. Regardless of the condition, the most common role was co-creator (N=22) which refers to situations in which both children contributed in the same proportion to the story, which can be done by suggesting new ideas or enriching peer's ideas. Occasionally they acted as followers (N=3), which could happen when a child would aimlessly follow the peer (G2,C3) or when the group (G6) had a child (C11) with a more dominant personality. Only in two control sessions, two groups (G4,G6) did not fully co-create part of the story as children acted as parallel creators, where one of them was isolated from the main action and mostly ended up by staying still while playing with toys, while the other child continued the main story creation.

In regards to the children's organization or task division, groups followed different strategies. Most of the groups (G1,G2,G3,G4,G5,G6) created the story while exploring the prototype and its different outputs. However, two groups (G7,G8) decided to define the scenarios before exploring the space and sounds, adapting the scenarios during the story.

Children preferred the robot that had emotional behaviors After completing both sessions, we asked children which robot they preferred to play with. We then applied the Chi-Square test, and we can infer that the preference is statistically significant ($X^2(2) = 12.5, p = 0.002$), as children preferred the emotional robot(N=12) when compared to either the turned-off robot(N=2) or situations in which there was no preference(N=2). From the children who preferred the emotional robot, ten justified that choice with the robot's movement, six preferred its sounds, and only two mentioned its lights. It is relevant to take into consideration that each child might have given more than one reason.

VI. Discussion

In this section, we answer the proposed research questions, discuss limitations, and describe future work.

A. Are multisensory environments and robotic devices effective in supporting inclusive storytelling experiences? (RQ1)

Our Inclusive'R'Stories provided a multisensory environment during the storytelling activity due to its tactile, auditory, and visual elements. Such elements supported an inclusive experience as children interacted with the prototype differently but evenly; some used each stimulus alone while others used them in combination. For instance, the different textured spaces and the toys encouraged the tactile exploration of the prototype by fostering children to explore the entire workspace to find a specific toy and move it around as they pleased. Another factor contributing to our prototype's inclusiveness was the use of buttons to trigger sounds and the robot's behavior. Children pressed them to start exploring a new room or repeat the robot's behavior, which they could integrate into the story (e.g., to score a goal). Therefore, buttons were essential for generating ideas, providing children with VI the same opportunities to perceive the situation and interact as their sighted peers. In fact, one of our participants, a blind child (C7) who previously had barriers in creative activities, was able to perform, create and engage with the storytelling activity. This observation motivated her teacher and psychologist to re-adapt her classroom work and to apply her storytelling experience to concrete curricular tasks.

To address the impact of robotic devices in inclusive experiences, we specifically compared the robot's emotional behavior to a control condition where the robot had no behaviors. As part of the multisensory environment, the robot expressed emotions with multimodal behaviors, through movement, color, and sound. Such design consideration allowed children with and without VI to engage autonomously in the storytelling activity. Our results support that the expression of emotional behavior increased children's interactions with the robot, either by its physical manipulation or overall engagement with it. Furthermore, when the robot had emotional behaviors, children with VI manipulated and physically engaged with the robot significantly more than their sighted peers, as they used touch for tracking its movement. Our findings suggest that the different feedback types - lights, textures, movement, and sound - used to describe the environment and the robot's behavior were of utmost importance. Therefore, our study aligns with prior work in mixed-visual ability contexts [16], [38], and suggests that multisensory environments and robotic devices can effectively support inclusive storytelling experiences.

B. How do the robot's emotional behaviors affect the content of the story? (RQ2)

We analyzed the stories children created in terms of creative and emotive elements. We did not find evidence that the robot's emotional behavior can influence children's creativity. We believe that the multisensory workspace and the diversity of toys within Inclusive'R'Stories might have strongly encouraged creativity (more than the robot's behavior). Aligned with prior studies showing that tangible objects can foster creativity [2], [6], [7], [11], [12].

However, we found an interesting effect of the robot's emotional behavior on the emotive elements used by children to create their stories. Children significantly added more emotive elements to the story when interacting with the emotional robot when compared to the control condition. For example, in one group (G7), when "Rose", the robot, was angry the teacher character called her to an isolated place to understand what was happening and to help her to calm down. These results seem to be coherent with previous findings from the psychology and HRI field, [8], [26] where emotions elicit affective responses. Upon observing the story segments created as a consequence of the robot's behaviors, the robot showed potential to develop children's emotional regulation, a vital skill for positive relationships [26]. Additionally, as there was no difference between conditions regarding the attribution of emotional elements to the other characters, it seems that the robot plays a catalyst role in the inclusion of emotion in the story. Overall, the expression of emotional behaviors by the robot increased the number of emotive elements in the story.

C. What strategies, roles, and behaviors do children adopt in mixed-visual ability storytelling activities? (RQ3)

Children engaged with each other and with the activity and, as expected, had several moments of negotiation, dialogue, and discussion. All children used the space, the robot, and the toys to co-create their story independently of their visual acuity. Interestingly, we did not find any difference in the number of accessibility requests and supplies between conditions.

In terms of roles, children were overall co-creators and interchanged roles depending on the story phase. However, as expected, sighted children often played as logistic supporters. Regarding the collaboration during the story co-creation, the flow of ideas between peers was similar across conditions. However, the number of times a child explicitly accepts his peer's ideas was significantly higher in the experimental condition. This result suggests that robots conveying emotions can influence children's acceptance of each other's ideas or, in other words, their collaborative actions. Linking this finding to the ones discussed in Subsection VI-B, it seems that children displayed more empathetic behaviors when they played with the robot expressing emotions.

D. Recommendations for Inclusive Activities with Robots

Our work yielded a set of recommendations that can guide the design of inclusive activities with robots. First, the **Multimodal Robotic Behavior** (through light, movement, and sound) is crucial to support the perception of the robot by the children. Second, the use of a **Multisensory Environment** —in the form of tactile, auditory, and visual feedback— stimulates the autonomous exploration of the environment and immersion in the activity. For example, the robot's movement and the room's auditory feedback triggered the exploration of the workspace, while tangible interaction supported engagement and collaboration between children. Finally, the **Relation between Task Nature and Abilities** should create equal opportunities for participation and reduce asymmetry between children's abilities. For instance, the nature of our storytelling activity was purely creative, and children could contribute by generating ideas and narrating them. We targeted a common modality of interaction to balance the experience and maintain the engagement and interest of both children.

E. Broader Implications on Inclusive Education

Our Inclusive'R'Stories prototype can be a tool for social learning activities as it elicits meaningful social interactions in several ways. First, the collective perception of the activity and the required shared communication between the children contributes to their learning about inclusion. Second, the creativity element combined with role-playing allows children to develop emotional regulation strategies during the storytelling activity. Our experiment further suggested the robot and its emotional behavior might also promote the use of those social skills. Additionally, Inclusive'R'Stories provides another learning opportunity regarding spatial skills due to the physical workspace that accommodates children's stories. One of the features of the Inclusive'R'Stories prototype is its flexibility regarding the thematic content it provides for the story creation. By adapting the sounds triggered by the buttons and adding/removing some of the toys, the spaces can easily be perceived as something else beyond the school theme (e.g., classroom, playground). Therefore, we envision a broader application of a similar storytelling tool in educational or therapeutic settings by creating spaces related to the learning contents or the therapy session.

F. Limitations and Future Work

This study included 16 children, which is a small number of participants. However, they represent a crucial user group when designing inclusive education technologies and when identifying challenges in mixed-ability settings. Although results can differ with a larger sample, the derived insights of this study may still apply. For instance, using multisensory workspaces, robotic devices, multimodal behaviors, and giving interactive control to children seem to support their co-creation activities effectively. Further research should conduct longitudinal studies to assess its impact on creativity and emotional story expressiveness and its impact on children's emotion-regulation skills and inter-play in mixed-visual ability contexts. In this study, children were restricted to the available toys and predefined robot emotional behaviors, which could have limited their creativity. An interesting research avenue would support children to co-create with other toys, environmental sounds, and novel robot behaviors.

VII. Conclusion

In this paper, we proposed Inclusive'R'Stories, a multisensory storytelling prototype where robotic devices are used in an interactive storytelling activity with mixed-visual ability children. Our novel approach elicits children with and without VI to co-create stories using a robot with emotional behaviors.

We conducted a within-subjects user study in which children tested our prototype in two conditions: the experimental condition in which the robot displayed emotional behaviors and the control condition, in which the robot was turned off. Results show that all children evenly participated in the activity, suggesting that children with VI had access to the same information and opportunities as their sighted peers, making our prototype inclusive. Although the robot's emotional behaviors did not influence children's creativity, it affected the amount of emotional expression used in the story, as children included significantly more emotional elements in the stories when using the emotional robot. Additionally, they explicitly accepted more peers' ideas on this same condition. Finally, we were also able to observe the different strategies used when mixed-visual ability children co-create stories and which roles did each takes. In addition to the promising results of this study, further research is required to measure the impact of the emotional robotic behaviors in children's creativity and emotion-regulation as well as to analyze how interactive storytelling in a mixed-visual ability context affects children's perceptions of uniqueness and inclusion in the long term.

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