

Experiencing Embodied Creativity through a Tangible Storytelling Artifact

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Abstract. *Embodied creativity claims that cognitive mechanisms involved in creativity, such as idea generation, conceptual combination, and mental imagery, are facilitated by embodied interaction with the environment. Storytelling serves as a powerful tool to foster communication, collaboration, and creative thinking. By combining innovative forms of storytelling and contemporary technologies, it is possible to design immersive creative experiences. This work aims to explore and understand the role of embodied interaction in children's creative processes as they interact with Livro Mágico, a storytelling artifact designed to support meaningful story creation. We conducted a Case Study involving preschool teachers and children aged 5-6 in an educational setting. Participants collaborated to create physical representations of stories using NFC technology. Analysis of data collected shows how children's interaction with the storytelling artifact mediated embodied narrative experiences, and encouraged collaboration and imagination.*

1. Introduction

Creative and innovative thinking is essential for addressing the challenges of modern society. Traditional theories of cognitive science see cognition and creativity as abstract manipulation of symbols that occur only in the brain. In contrast, embodied theory argues that the cognitive processes arise from the dynamic relationship between the body-mind-world coupling [Varela et al. 2017]. This perspective emphasizes that cognition and creativity emerge through a real-time and improvised interaction with the environment and other agents in that environment [Engel et al. 2010, Varela et al. 2017]. [Davis et al. 2013] introduced *embodied creativity* as a subcategory of embodied cognition, arguing that creative cognitive processes, such as idea generation, conceptual combination, and mental imagery, are enhanced through embodied interaction with the environment. Embodied interaction, defined as “the creation, manipulation and sharing of meaning through engaged interaction with artifacts” [Dourish 2004], highlights the co-construction of meaning socially negotiated through bodily engagement with technological artifacts.

Among all different activities that could foster the development of children's creativity and cognition, storytelling plays an important role in helping children exercise their imagination, acquire and practice language styles, and explore evolving social roles

[Meltz 1999]. In early childhood, storytelling supports children's development by helping them express and assign meaning to the world, develop communication, recognition, and recall skills, and enforce their relationships with peers and adults. When children tell a story, they engage with ideas through narrative. By creating a physical representation of the story, they make it tangible and concrete, offering another way to reflect on these ideas. Tangible computational tools can make the symbolic and abstract manipulations involved in storytelling more concrete and manageable for young children [Cassell 2004]. For example, a toy that allows children to record parts of a story in oral language, can later invite them to physically organize these recorded segments. This enables them to engage in an editing process without relying on handwriting or keyboards, tools which they are not yet fluent with [Ryokai and Cassell 1999].

Technologies that enable embodied interaction are highly effective in supporting user engagement and creative expression [Carbajal and Baranauskas 2024, Price 2017]. Research on creativity commonly evaluates creative outputs or verbal articulation to assess children's ideas [Vass 2011], with limited attention to the body's role in creative expression. In this paper, we aim at identifying creative forms of bodily and social interaction, as well as emotional states, when children use a tangible artifact for storytelling. To explore this, we present an interactive experience where children create a story using the *Livro Mágico*, a tangible artifact incorporating Near Field Communication (NFC) technology. In collaboration with preschool teachers, we conducted a Case Study to provide an engaging, enjoyable, and fun experience for young children, while fostering new forms of creativity and enhancing the educational benefits of storytelling. Drawing on embodied interaction, we analyzed how the *Livro Mágico* shapes both bodily and social interactions, and its incorporation into the children's collective narrative. Furthermore, we used the *Adapted Emoti-SAM* [Carbajal and Baranauskas 2019] (an adapted form of the Emoti-SAM [Hayashi et al. 2016]) to allow children to express their opinions and feelings regarding the storytelling experience.

This paper is organized as follows: Section 2 reviews related works in technologies that facilitate storytelling. Section 3 details the methodology, including the technical implementation of the tangible storytelling artifact and research design. Section 4 presents the results from the workshop with preschool children. Section 5 discusses these results and findings. Finally, Section 6 concludes with contributions and directions for future research.

2. Related Works: Tangible technologies for Storytelling

In the literature there are projects that foster creative learning by combining innovative storytelling techniques with novel technologies. Below, we present creative experiences designed to engage children in crafting physical representations of their personal stories using tangible computational media.

Paper Electronics involves constructing circuits on paper [Qi and Buechley 2014] using conductive foils, tapes, or inks to connect electronic components such as lights, sensors, and programmable microcontrollers. Creators can express themselves by creating circuit patterns with conductive materials and decorating their circuits with traditional paper craft media. **Programmable Projections** [Panjwani 2017] are interactive Scratch [Resnick et al. 2009] programs projected onto

three-dimensional paper sculptures to create dynamic scenes on static forms. This project allows creators to integrate paper pop-up art with Scratch programming, connecting computation to the physical world. They can also explore with physical-digital interactions, such as turning a page to trigger an animation, directly on paper. **Sewable Circuits** [Panjwani 2017] are textile-based circuits created using conductive threads and fabrics to connect electronic components. With Sewable Circuits, creators can merge textile arts with electronic devices, incorporating programmable microcontrollers such as the Lilypad Arduino [Buechley and Eisenberg 2008] to design projects featuring lights and audio. For example, children combined sewable circuits with appliqué embroidery to craft quilt frames representing objects of emotional value and the experiences associated with them. **TapeStory** [Santos et al. 2025] is an interactive art installation designed to integrate the tactile qualities of weaving with capacitive sensor technology. These materials are connected to a microcontroller, which enabled touch detection and triggered audio feedback, including narrative elements from a narrator and characters.

These projects engage children with technology to create forms of stories, enabling them to represent personal experiences through craft, electronics, and projections while exploring computational and artistic concepts. The works emphasize creative expression through the production of perceptible artifacts, whether individually or collaboratively. However, they do not explore the role of these artifacts in promoting creativity through bodily engagement and social interaction. The authors [Slepian and Ambady 2012] argue that bodily movement influences cognitive processing, with fluid movement leading to fluid thinking or creativity. For young children, creativity draws on notions of everyday creativity, characterized by personal interpretation and ideation, including any novel, personally meaningful understanding of an experience [Kaufman and Beghetto 2009]. Regarding social interaction, [Vass 2011] highlights shared creative engagement, evidenced through spontaneously coordinated movement, associative thinking, and mutual influence on action.

In this context, our aim is to explore creative forms of bodily and social interaction among peers, and the emotional states evoked when using a tangible artifact for storytelling. The *Livro Mágico* is distinguished from the other TUI's storytelling systems by its specific combination of technology, interaction design, and data analysis focus, constituting a unique contribution to the field. We can detail this distinction between related works in the following way:

- *Livro Mágico* uses colorful papers embedded with NFC tags as its main interface and storytelling medium. While other TUI storytelling systems commonly utilize electronics objects and textiles, our system is unique in its integration of the ubiquitous NFC system (smartphone and tags) with low-cost user-customizable paper (see Section 3.2).
- The interaction design for *Livro Mágico* was co-designed with preschool teachers, ensuring that pedagogical considerations and practical classroom needs were incorporated. This approach helped in planning meaningful activities that promote creative thinking (see Section 3).
- The data analysis included physical engagement and social interaction, and provided insights into how the *Livro Mágico* mediated embodied narrative experiences (see Section 5).

3. Methodology

In this work, we explored the use of NFC technology to create the *Livro Mágico*, a storytelling kit for preschool children. NFC is a wireless technology that enables short-range data exchange, similar to Radio Frequency Identification (RFID) but targeted at mobile devices. Both technologies store data on passive tags that can be attached to various objects. Users retrieve data from these tags by touching them with a reading device, such as a smartphone [Want 2006]. This touch-based interaction has been increasingly adopted in applications [Broll et al. 2009], with results showing it is intuitive for adults and children to learn and use. When incorporated into games, it can enhance fun and engagement of the experience.

The experience with the *Livro Mágico* was co-designed with two preschool teachers participating in this case study. We began with a pilot session to demonstrate how NFC technology works to the teachers. After experiencing it firsthand, they agreed to use the NFC technology for the storytelling project. Particularly, teachers appreciated the ease of use with a smartphone, the familiarity of smartphones for children, and the opportunity to introduce children to alternative uses of the smartphone. The methodology was planned in four stages: 1) Collaborative story creation by the preschool class; 2) Participation in creation of the *Livro Mágico*, our tangible storytelling artifact; 3) Interactive workshop with the *Livro Mágico*; and 4) Evaluation of children's experience.

3.1. Collaborative story creation by the preschool class

In the first stage, following preschool practice, the story was created collectively with children alternating between creator and listener roles as they interacted with the story as it was being created. The teachers guided this process and reported that children actively participated by raising their hands to suggest how the story would proceed, trying to further the previous idea. Using the "Beginning, Middle, End" framework [Maike and Baranauskas 2014], which utilizes the power of narrative to encourage children to use their imagination, the teachers drew from "Little Red Riding Hood". Most children participated with interesting suggestions, with the teachers transcribing all ideas. The final collaborative story (translated from Portuguese) appears in Table 1.

3.2. Participation in creation of the tangible storytelling artifact

Regarding the second stage, each child narrated one part of the story and their voices recorded in MP4 format. We associated each audio recording to a unique NFC tag. We saved the voice recordings as MP4 files on a smartphone, and we used an Android application to program each NFC tag to trigger playback of its corresponding audio file. The decision to use just sound in the cards was taken in conjunction with the teachers, aiming to generate greater surprise and impact when children discovered their own voices telling the story, and demonstrate the system's flexibility by showing how cards could be reprogramming with new recordings for different stories. The final *Livro Mágico* consisted of 13 pages that children could explore by scanning with an NFC-enabled smartphone (see Figure 1).

As illustrated in Figure 2, the *Livro Mágico* system comprised three main components: i) a smartphone equipped with an NFC reader, a Android application installed, and Bluetooth connectivity; ii) colorful physical papers embedded with NFC tags, and iii) a

Table 1. The collaborative story created by the children

Once upon a time there was a beautiful school! Children played all the time! One day, they went on a trip to a fairy tale. They saw three wolves. They didn't know they were nice, so they ran, ran until they were lost. Then a boy saw a trail, so they found their way back. Soon it started to rain. The children found a super cave. It was the home of the wolves. There the wolves served warm porridge, but the children messed up everything there. As the children were taking too long to get back to school, the rangers were already looking for them. During the search, the guards found the tracks of the children entering the cave of the wolves. They entered quickly and found all the children's mess! Even the wolf cubs were making a mess! The wolves had their tails, hair and ears up. The guards, when they saw it all, were happy because they found the children. Before going back to school, the children helped to organize the entire cave of the wolves. As it rained a lot, outside the cave it was pure mud, so they couldn't get out. They stayed there for two days until it stopped raining. On the third day, when the sun came up, they were able to leave the cave. They said goodbye to the wolves and were able to return home. And then, live happily ever after!!!



Figure 1. The *Livro Mágico*, a tangible storytelling artifact

Bluetooth speaker. The system operates as follows: When a child passes the smartphone over a NFC tag, its identifier is transmitted to the Android application. The application then verifies if the identifier exists in its registry; triggers playback of the corresponding MP4 voice recording; and routes the audio output through paired Bluetooth speakers.

The third stage of the experience with the *Livro Mágico* artifact will be detailed in the following section.

3.3. Interactive workshop with the children

The workshop was conducted at a Children Living Center (CECI- Portuguese acronym of *Centro de Convivência Infantil*), a daycare center located on the campus of the University of Campinas (UNICAMP). This center provides care and education for children aged six months to six years, while their parents work. This case study is part of a project approved by the university's research ethics committee under the number 72413817.3.0000.5404 [Baranauskas 2015]. For this workshop, we worked with one preschool class with two teachers and 14 children (4 girls and 10 boys, aged 5-6 years). The workshop lasted 90 minutes and it was documented by video and photographs with institutional permission. All participants (teachers, parents, children) signed a free and informed consent form. The children's form was written and explained in age-appropriate language.

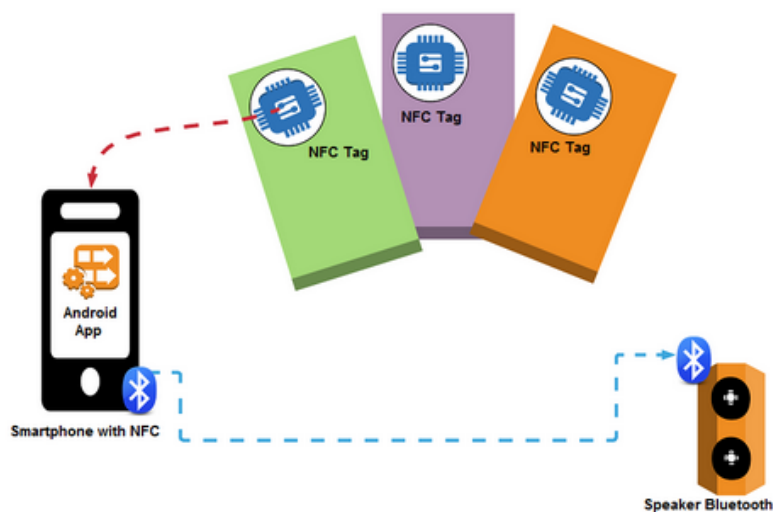


Figure 2. Operation of the *Livro Mágico*

Following the teachers' suggestions, we conducted the activity with the entire class (see Figure 3). The workshop began by explaining the activity and asking the children to explain how the *Livro Mágico* might work. Then, we showed the NFC-embedded colorful papers and demonstrated how they work using a smartphone. Next, the children experimented with the NFC-embedded pages and heard the story's fragments recorded in them. Finally, with the help of all children, the pages were arranged inside the *Livro Mágico*.



Figure 3. Children experiencing the *Livro Mágico* artifact

3.4. Evaluation of children's experiences

We finished the workshop with an evaluation of the experience by applying the *Adapted Emoti-SAM* [Carbajal and Baranauskas 2019], which consists of a paper-based scale featuring 5 emoticons ranging from the most positive option (happy face with the thumb-up)

to most negative (disappointed face). Also, the form included a blank drawing space (per teacher's suggestion) so that the children could freely express their feelings about the activity through their drawing too (see Figure 4). We asked children to draw their favorite workshop aspect. Drawings proved to be a particularly effective evaluation tool as they represent a universal and enjoyable activity for children [Xu et al. 2009]. Drawings are a rich source of information on children's experiences, providing an efficient way to elicit a large amount of accurate information (as no training or practice is required) [MacPhail and Kinchin 2004]. This method is valuable for children who have limited writing skills or who feel insecure about communicating verbally with researchers.

Date: _____ Age: _____ Gender: Female _____ Male _____






				
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Figure 4. *Adapted Emoti-SAM form* [Carbajal and Baranauskas 2019]

4. Results of the Case Study

We conducted a comprehensive analysis of children's embodied interaction with the *Livro Mágico* through detailed transcription of verbal exchanges, physical interactions, and spatial organization. The analytical process involved iterative viewing of video data of the workshop, detailing interaction sequences and identifying creativity expressions.

4.1. Embodied Interaction

In this paper, we use embodied interaction in its practical sense to denote direct body-based interaction. The children engaged with the *Livro Mágico* for a 45-minute session. For most of the interaction, the children sat on the floor and formed a circle (see Figure 3). When a child read an NFC tag, the others generally moved closer to her/him. Occasionally, children got up to help a classmate read the NFC tag. The children's attention was generally focused on the smartphone when a child tested a NFC-embedded page. During the interaction, the children first placed the page on the floor and then passed the smartphone over the NFC tag. The use of a smartphone to hear their self-narrated story was clearly an exciting process for them. We also observed that more verbal students often influenced the group's dynamic, leading to different embodied forms. In Table 2, we present fragments of the detailed transcript that exemplify the children's embodied interaction, including their actions and verbal communication.

Table 2. Fragments of video transcription (translated from Portuguese)

Fragment 1: Girl4 does the reading and when the group listens to the audio, Boy1 begins to tap their feet imitating the part of the story: "...they ran, ran until they were lost...". Then other children (Girl2, Girl3, Girl4 and Boy9) imitate his movements.
Fragment 2: Girl1 performs the reading. After hearing the part of the story that says: "...soon it started to rain...", children imitated the sound of rain with their voices and began to wave their hands.
Fragment 3: The last two girls in the circle, Girl2 and Girl3 get together to pass the smartphone. Girl2 imitates the sound of the wolf when she heard the part of the story that said: "Even the wolf cubs were making a mess! The wolves had their tails, hair and ears up" Girl2: "Auuuuuuuuu!!!" Hearing her friend, all the children began to imitate the sound of the wolf. All children: "Auuuuuuuuu!!!".

4.2. Feedback from the *Adapted Emoti-SAM* form

Regarding the *Adapted Emoti-SAM*, the children indicated, in a range of emoticons, their affective states about the workshop, painting the desired emoticon. All children selected the highest happiness emoticon (a smiling face with thumbs-up). This unanimous preference strongly suggests the workshop was perceived as enjoyable and engaging by all children. For a correct analysis of the drawings, the children were asked individually to talk about what they had drawn. Figure 5 shows a drawing and its respective explanation.



Figure 5. Example of *Adapted Emoti-SAM* drawing. Child's explanation: "My friend, the teacher, the book, the pages of the book"

Table 3 presents the children's literal explanations (translated from Portuguese) for their drawings, which they provided when asked by the researcher. According to Table 3, eight out of fourteen children mentioned that they drew the *Livro Mágico* in their form. Furthermore, during the interview, we identified that five children renamed the NFC tags as "code" and used the expression "page with code" or "pages of the book with code" to refer to NFC-embedded pages of our storytelling artifact. In their drawings and during the interview, the children also identified other technological objects such as the smartphone used to read the NFC tags and the camera used to film the workshop (which was part of the workshop setting). An important social aspect that was evidenced and confirmed during

the interview was the presence of the workshop's participants in the drawings. Seven children drew at least one participant (a friend, a teacher or the researcher). Moreover, four children drew themselves using the smartphone to read the NFC tag.

Table 3. Children's explanations about their drawings

Age	Gender	Children's explanations
5	F	<i>She is me, the page with code, the Livro Mágico</i>
5	F	<i>My friend, the cell phone, the book page with code</i>
5	F	<i>The book, the tree, the robot</i>
5	M	<i>The camera filming everything, the researcher, the children at school, the pages of the book with code</i>
5	M	<i>Planet earth, the tree, the clouds, the teacher riding a bike, ball, here is a tree rising, sun</i>
5	M	<i>The tree, the camera, the door, the kids in our class, cloud, the Livro Mágico</i>
5	F	<i>The papers with code, the Livro Mágico</i>
6	M	<i>A table with two tires, one big and one small, a car</i>
5	M	<i>My friend, the teacher, the Livro Mágico, the pages of the book</i>
5	M	<i>A challenge coin, super coin, book</i>
6	M	<i>The rainbow, a mountain, the cloud with the rain, He is me</i>
5	M	<i>She is my friend, the cell phone</i>
5	M	<i>He is me, my friend, my friend jumping for joy, the code, the researcher</i>
5	M	<i>This is the trail of the robot, this is the robot, He is me</i>

5. Discussion

The workshop provided insights into how children engaged with *Livro Mágico* artifact. We collected data regarding the children's actions and speech as they organized their story inside the artifact. The analysis conducted was supported by the videos recorded during the workshop and aimed to identify forms of creative expression in the experience with the artifact, manifested through bodily and social interaction.

5.1. Embodied Creative Expression

Our behavioral observations revealed that children engaged with our storytelling artifact through dynamical verbal and bodily manifestations, demonstrating both freedom and enthusiasm in their interaction. The analysis highlights how interaction with the *Livro Mágico* mediated embodied narrative experiences through: *embodied story representation*, for example, when the children did sound of the rain and moved their arms during story segment that talks about rain was reproduced, when they stomped feet enact running sequences from the story, when they vocalized the howl of wolf; and *shared embodied experience*, for example, when they synchronized physical responses to the most striking parts of the story, when they coordinated spontaneous sounds and movements.

The children were involved in a personally meaningful storytelling experience through their physical engagement with the *Livro Mágico* artifact. The product's idea, in this context, is ephemeral due to the nature of the interaction (it is not a persistent resource). Instead, it is a transient narrative, and therefore only tangible to the children engaging in it.

5.2. Social Affordances

The storytelling artifact, *Livro Mágico*, was designed to foster significant social interaction and collaboration among children, which in turn contributed to their creative expressions and emotional engagement. The artifact's sounds consistently drew children's attention and generated active socialization. The shared experience of the story, mediated by

the artifact, allowed children to collectively explore imaginative scenarios and emotional responses, which are important for creativity [Russ 2003]. Furthermore, the artifact fostered immersion in the storytelling experience and contributed to narrative development through spontaneously coordinated shared movement.

5.3. Children's Emotional Engagement

When asked to indicate their emotional states using the *Adapted Emoti-SAM* form, all children selected the emoticon that represents the greatest happiness. This unanimous preference suggests the workshop was highly enjoyable and engaging. We observed that children were particularly excited to hear their self-narrated stories, highlighting a strong positive emotional response. Their active involvement in narrating parts of the story significantly contributed to this emotional connection and excitement. In their drawings, the majority of children drew the *Livro Mágico*, indicating it was a primary focus of their attention and enjoyment. Analyzing the children's drawings, eight children (four girls and four boys) drew the *Livro Mágico*. One boy drew the smartphone, while five boys drew other objects unrelated to the story or workshop (e.g. a rainbow, a mountain, a cloud). This suggests that these children explored their imagination beyond our instruction to draw what they liked most about the workshop.

5.4. Lessons Learned

The development and evaluation of the *Livro Mágico* artifact in a real educational setting provided valuable insights:

- Employing multiple data collection methods (video observation, emotion scales, and drawing analysis) provided robust evidence of children's engagement. This lesson reinforces the importance of mixed-method research when evaluating educational technologies with children.
- Our tangible artifact functioned as a driver of social interaction. Its sounds consistently attracted collective attention and generated moments of synchronization and spontaneous coordination among the children. This transformed the storytelling activity into a shared, co-constructed experience. This lesson highlights that the success of an educational artifact may reside in its ability to mediate and foster collaborative social interactions among students.

6. Conclusion

Fostering creativity is fundamentally important for developing 21st-century skills. Stories offer children a means for self-expression and sense-making about the world around them. The spontaneous stories that children tell are remarkably creative, dynamic and collaborative. In this work, we explore the shared design and creative interaction with the *Livro Mágico* artifact. Our results reveal how bodily engagement, socialization, and emotions constitute the interaction experience. The idea of *Livro Mágico* provides multiple pathways for children to develop new ideas, allowing them to view a familiar device (a smartphone) in new ways. For teachers and children interested in storytelling, NFC technology can serve as a tool for constructing new learning materials and engaging with computational concepts. Furthermore, activities carried out with teachers reinforced the importance of educator involvement in planning meaningful activities that foster creative thinking within a technology-based scenario. Future work will investigate aspects of embodied creativity within learning environments built with wearable technologies.

Data Availability

The dataset associated with this case study is publicly available in *Repositório de Dados de Pesquisa da Unicamp* (REDU): <https://doi.org/10.25824/redu/ECPLAW>

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