História Viva: A Sketch-Based Interactive Storytelling System

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***Abstract* — Storytelling is a powerful tool to convey values and enrich creativity, imagination, and critical thinking. However, digital native children are losing interest in traditional folktales as these stories now have to compete with more appealing and interactive forms of entertainment, such as videogames. New technologies allow stories to be told in different formats as digital interactions provide new experiences that can be more attractive for Generation Z children. In this context, sketch-based interaction stands out as a powerful tool to keep children interested and engaged in interactive folktales. This paper describes the design process that led to the development of a sketch-based interactive storytelling system, called História Viva, which was designed to transform traditional folktales into interactive narratives. The system explores Portuguese folktales and was designed for children within the age range of 6 to 11 years old. Preliminary results from a user study indicate that children are very receptive and entertained by the proposed interactive narrative.**

Keywords — interactive storytelling, folktales, interaction design, sketch-based interaction

I. INTRODUCTION

The influence of digital technology on human dynamics is steadily on the rise. From economics to politics and culture, technology is changing human behavior by becoming so incorporated in the new generation's life that children are evolving into digital natives. The study of interactions between children and computers has been getting more attention over the past few years, especially because members of the Generation Z are growing up using and knowing the verbal and visual world of the internet [1]. The relationship between children and technology has different perspectives, however, this study focuses on its positive aspects, like the potential that technology has to hold children's attention while interacting with stories [2].

Stories have been told since the beginning of time and, as part of folklore, it contributes to the perpetuation of values and cultural traditions. Scholars recognize that folklore is one of the building blocks of children's literature and it is therefore an important social asset which represents culture and behavior [3]. However, current children are reading less than past generations [4]. The loss of interest in traditional folktales is eminent as these stories are not updated with the new technologies available. As a natural extension of the current era, storytelling has to embrace new technologies to be appealing to an audience that is digitally connected and interested in new forms of interaction.

In many settings, traditional storytelling may be considered old-fashioned, especially nowadays that children have more digital distractions than ever before [5]. In this context, the evolution of technology can contribute with different possibilities to transform the way people consume and interact with stories. In particular, the use of hand-drawn sketches as a form of interaction for interactive storytelling is showing promising results [6][7][8]. According to Druin et al. [9], children enjoy telling stories and they love to draw. Therefore, drawing can be an attractive form of expression to strengthen the connections between children and folktales. According to Paulson et al. [10], the act of drawing explores the four main pillars of children's basic learning (auditory, visual, tactile, and kinesthetic). In addition, sketch-based interaction can increase children's sense of authorship as their drawings are used for the development of the narrative [6].

This work presents the development process of a sketch-based interactive storytelling system, called *História Viva*, which was designed to transform traditional folktales into interactive narratives. The system explores Portuguese folktales and was designed for children within the age range of 6 to 11 years old. In this paper, we describe the design process of *História Viva*, and the results obtained in a user study conducted to evaluate the system's usability and the children's responses to the sketch-based interaction model.

The paper is organized as follows. Section II presents related work. Section III describes the design process that led to the development of *História Viva*. Section IV presents the results of a usability test conducted to evaluate the proposed interactive storytelling system. Section V offers concluding remarks.

II. RELATED WORK

Sketch-based interaction is an active research topic in the area of human-computer interaction [11]. Although the applications of interaction methods based on hand-drawn sketches are numerous and widespread, this related work section focuses primarily on interactive storytelling systems that use sketch-based interaction methods. A more general review of the state of the art on sketch-based interaction is presented by Bonnici et al. [11].

One of the early inspirations for the use of hand-drawn sketches as a form of interaction for interactive storytelling comes from Crockett Johnson's children's book titled *Harold and the Purple Crayon* [12], which was first published in 1955. Although the book is not interactive, it tells the story of a boy who uses his purple crayon to create images that come alive and take him through numerous adventures.

The Lost Cosmonaut [13] is one of the early interactive storytelling systems to adopt hand-drawn sketches as a form

of interaction. The system is an art installation that provides narrative units (text, images, and sounds) as result of user's strokes on a special paper. The audience can also actively produce content for the narrative by writing and drawing on the paper. The audience's contributions are added to a database and displayed for future users. The system relies on a special pen, known as the Anoto Digital Pen, to record the pen strokes and send the drawing information to a computer.

Another interactive storytelling system that relies on the Anoto Digital Pen is *Papyrate's Island* [8], which is capable of transferring the users' 2D drawings to the 3D virtual world of the story. The system uses the context of the narrative to establish the functionality of the inserted objects. For example, users can draw a fire-extinguisher object when requested. In this case, any object draw by users will be considered a fire-extinguisher and the direction of the water jet is defined by the final stroke of the pen that moves from the drawing to the margin of the paper.

The combination of sketch-based interactions and augmented reality in an interactive storytelling context is explored by Lima et al. [6][7]. The authors present a mixed reality system called *Draw Your Own Story*, where the users can interact with virtual characters in an augmented reality environment as they draw objects to help the main characters on a piece of paper using a regular pen or pencil. Their user study revealed that "the use of hand drawings as a form of interaction improves user satisfaction, experience and the system usability" [6]. Their system was also extended by Franco and Lima [14] to support the recognition of generic hand-drawn sketches of environmental objects, such as clouds and walls, that modify the environment of the virtual world. A similar approach is explored by Feng et al. [15] to create 3D cartoon scenes based on children's drawings.

There are also applications for mobile devices that explore storytelling and drawings. One example is the mobile game Draw Story [16], which was launched in 2019 for Android and iOS. In the game, the main character goes through several challenges that require the player to draw objects to help the character escape from the situations. However, the story is not branched. The objects draw by the player are only used to move the story forward.

Although sketch-based interaction methods have being used in several interactive storytelling systems, most previous works focus only on the technical aspects of the sketch recognition process. Currently, there is a lack of studies on the design process of sketch-based interactive narratives. Therefore, the present work focus on describing the design process that led to the development of *História Viva*, which can be used as an example to guide the development of future interactive storytelling systems.

III. História Viva

Storytelling is a powerful tool to convey values and can also enrich creativity, imagination, and critical thinking [17]. Currently, Generation Z children are digital natives with plenty of online distractions and parents are missing important moments to share classic stories [5]. Therefore, there is an opportunity to give a new approach to storytelling with digital interactions that would be more appealing to children [18]. In this context, sketch-based interaction stands out as a powerful tool for children that can contribute to keep the user interested while increasing the sense of authorship [6][10]. This scenario led us to propose a new a sketch-based interactive storytelling system called *História Viva*, which aims at providing an environment where children can interact with folktales using drawings.

História Viva was designed for Portuguese children within the age range of 6 to 11 years old, which is based on the age recommendation of the Portuguese National Reading Plan for folk storybooks [19]. The next subsections outline the design process of *História Viva*.

A. Exploratory Study and the Development of Personas

The creation of a system that accommodates the needs of a diverse variety of users can be problematic since it increases the cognitive load for all of them. The best way to design successful products is to have specific types of individuals (or groups of individuals) and their specific needs in mind [20]. According to Cooper et al. [20], developing personas helps to understand a variety of people and their expectations, providing a tool that allows the designer to determine what a product should do and how it should behave. According to Rubin and Chisnell [21], personas are evidence-based characters of archetypical users as they represent behaviors and goals that will facilitate the understanding of the users.

In order to create the personas for *História Viva*, a preliminary qualitative research using a semi-structured interview was conducted for an exploratory study about children, their parents, and folktales. This exploratory data was gathered through a survey and was used to build fictional personas considering the needs and limitations of each user.

For this exploratory study, two surveys were created to help gather more information about potential users. These surveys were conducted online, through Google Forms. One survey was directed at parents, and the other at children in order to distinguish information provided by these separate points of view. The questionnaires were semi-structured and contained both closed and open questions. The link to the questionnaire was sent by email to a group of acquaintances' parents and children. The children's questionnaire was composed of 12 questions that explored whether children liked stories, knew about folktales, what their favorite stories were, etc. For the parents, the survey comprised 21 questions related their profession, reading habits they have with their children, and the devices they use.

Thirteen people participated in the survey: 8 adults (parents) aged between 31 and 50, and four children aged between 7 and 12. All the children said they knew at least one Portuguese folktale, but there was no common answer to their favorite story. When asked about their favorite story, they all responded with foreigner narratives, like *Beauty and the Beast*, *Red Riding Hood*, and *Felicity Wishes: Friendship and Fairy School*, among others. All of them liked stories and all of them would have liked to play with a story that would change according to their interactions. The most used devices daily were TVs (75%), tablets (25%) and mobile phones (25%). The adults also said they knew at least one Portuguese folktale, but some mentioned *Little Red Riding Hood* as Portuguese. All of the parents read for their children whenever possible, usually before bedtime.

Based on the information gathered through the exploratory study, two personas were developed: the child Carla (Fig. 1) and the parent Fabi (Fig. 2).

1) Carla

Name: Carla

Age: 8 years old

Nationality: Portuguese

Residency: Lisbon

Occupation: Student

Fig. 1. The first persona: Carla (a child).

Carla's Description: Carla likes to hear and read stories. Her favorite story is the *Beauty and the Beast*. Sometimes her mom reads for her, usually before bedtime. Her favorite Portuguese tale is *O Cuquedo* by Clara Cunha e Paulo Galindro. She loves to play games. Carla would like to go to the park where she can play with her friends and walk the dog as she plays Pokemon Go. Her main frustrations are having to go to bed when her parents tell her to, and that her teacher tells her the same stories all the time. Also, due to the COVID-19 pandemic, Carla cannot go to the park that often anymore. Carla loves to draw. She uses her smartphone, her mom's tablet, and TV as her daily devices. She is very curious, smart, and has lots of energy.

Carla's Journey: Carla is frustrated because she cannot go to the park regularly. Due to the lockdown, she is often inside the house. At least she is happy to have her parents at home with her. Carla likes stories, especially Disney ones. She gets frustrated with her remote class when her teacher tells them a folktale and she cannot interact with it. Her mother sees her frustrations and decides to download the *História Viva* app on her tablet and her laptop. Later that day, her mom asks her if she knows any Portuguese folktales. After thinking a bit, she answers: *The Little Prince*. Then, her mom, Fabi, asks her to sit next to her as she is going to show her a real Portuguese folktale. Carla is very excited about it. Three magic doors appear on the screen and her mom asks Carla to decide which one to open. Carla opens a door and the story begins. Carla is speechless. It is like magic. As the story progresses, Carla needs to interact with the plot, giving it various possible endings. The main character is in a very dark place and light is needed to help him find his way out. So, Carla immediately draws a sun on the tablet. The sun shines inside the story and immediately lights up the room, helping the character to go to a different place. After the end of the story, Carla is fascinated by the experience. She asks her mom more about the storyline, in which Fabi explains that is from a Portuguese folktale, found in José Vaiale Moutinho book called *Seis Histórias Tradicionais Portuguesas*. Now Carla wants to try different drawings to see if the story changes.

2) Fabi

Name: Fabi

Age: 42 years old

Nationality: Portuguese

Residency: Lisbon

Occupation: Front-end developer

Fig. 2. The second persona: Fabi (a parent).

Fabi's Description: Fabi is a very dedicated and hard-working mom. She loves programming and experimenting with new recipes in the kitchen. She takes turns with her husband to read for her daughter, Carla, but sometimes it is simply not possible. Because of the pandemic, she is working remotely from home. Her goal is to balance work with helping Carla with school while also coping with Carla's frustrations since they are all at home. Her main frustration is the noise in the house which makes it difficult to concentrate as her daughter and her husband are stuck at home with her. She loves to be outside as well, so in current times when this is restricted, everything is becoming more difficult. Fabi is a very sweet and attentive woman who pays attention to details.

Fabi's Journey: Fabi has just returned from the supermarket. A positive outcome of the pandemic is that she is able to cook every day. She is a developer and very attentive to the detail in everything she does. After cooking lunch, she notices that her daughter, Carla, is a bit frustrated with the restriction measures due to the pandemic. Carla loves to go outside, and she also misses going to school and meeting her friends. After talking to Carla and seeing her frustration with remote schooling, Fabi recalls an app that might help Carla to interact with folktales. She first downloads the system and installs it on her computer. Then, she downloads the app and installs it on her mobile phone. At the same time, she needs to talk to her husband who is making a lot of noise due to the number of meetings that he has daily. Fabi calls Carla and shows her *História Viva*. Fabi reads the explanation on how the system works and both of them are very excited to share this experience. The story's animation begins once Fabi connects the laptop system to the mobile app. Carla can interact by drawing on her mom's tablet and the animation progresses with her interactions. Fabi is very fascinated by the experience as well, especially seeing her daughter very happy while interacting with the system. She notices that Carla was particularly impressed by the act of drawing on one device and the story changing its plot, on another. After Carla's experience, she shows her daughter the book that inspired *História Viva*'s animation.

B. The Folktale and User Interactions

The decision to work with a folktale as base for *História Viva* is founded on the importance of preservation, adaptation, and innovation of folklore for children [22], and also in the inclusion of folk storybooks in the Portuguese National Reading Plan [19]. *The Stone Soup* (*A Sopa de Pedra*) was the folktale chosen to be the basis of *História Viva*. It is part of *Seis Histórias Portuguesas* by Moutinho [23], which is in the recommended literature of the annual reading plan for 4th cycle children [19]. This specific tale was selected because it contains rich cultural elements that can be explored, including religion, compassion, food, the values of sharing, and acceptance of newcomers.

The Stone Soup is a traditional European folktale where a hungry foreigner persuades the residents of a village to share their ingredients for the preparation a soup, which has a stone as the main ingredient (in some variants, the stone is replaced by other objects, such as an axe, button, nail, and wood). The story falls under the "clever man" category of the Aarne-Thompson-Uther Index [24][25]. No exact date can be found when it was first published in Portugal, but it became very popular and associated with the region of Almeirim, where the tale and the soup itself became a national delicacy and can be found in restaurants and supermarkets all over Portugal [26]. One of the earliest versions is attributed to Teófilo Braga, who presented the tale in 1883. The contemporary author José

Viale Moutinho also wrote a few different versions of *Stone Soup* [27]. Moutinho's stories presented different main characters and titles. In two versions, the friar is the traveler, where in another the friar is the one that hosts the traveler [26]. José Viale Moutinho is an award-winning Portuguese writer, who has authored about fifty books for children [23].

História Viva was created using the *Stone Soup* tale as a base narrative and branches were added to create the other possibilities in the story. One of the challenges of making *Stone Soup* interactive was the fact that the story itself needed to be adapted as the user will be able to change the story's paths with their drawings. Branching path stories allows the user to make choices inserted at certain points as they progress along with the story [28]. While some decisions have a minor impact on the story, others can change the path the characters are following completely, so this type of story will always have multiple endings. Since creating branches means complementing the story with different scenarios, the challenge here was the introduction of other elements. For that matter, elements from other folktales written by José Moutinho were introduced. For *Stone Soup*, Moutinho [23] presents two main characters, the traveler and the owner of the house (host). It was observed while reading *À Lareira* [27], a book with a compilation of Portuguese folktales, that the female characters were hardly ever the lead of the adventure. Other characters were also often portrayed in several stories with religious roles (e.g., saints, friars, etc.), fantasy roles (e.g., royalty, witches, werewolves, etc.), and roles which portray the experiences of everyday life (e.g., marriage, love, betrayal, etc.), among others.

Women as lead characters in children's stories are in the minority of the literary works. According to the Interactive Media Foundation [29], 68% of books feature a male protagonist in comparison to 19% that have a female lead, in which the female protagonists usually have two main paths: marriage or tragedy. Even though this is not the focus of this study, it is important to note that embracing gender diversity in stories is something that still needs a lot of work [30]. Keeping that in mind, Ana is the lead character for *História Viva*'s story. The other characters are based on Moutinho's books referenced below and were selected based on the contribution they offer to the story. The friar is the host as per the *Stone Soup* story [23] and characters from other tales were added, such as the werewolf in *The Werewolf from Fareja* [26], Our Lady of Joy in *Joy, Cliff and Pleasures* [26], and wolves and gourds in *The Old woman and the Wolves* [27].

As an interactive narrative, the interaction elements to be added to the *Stone Soup* also play an important role in the process to define the possible storylines for the narrative. Since our system uses a sketch-based interaction model, these interaction elements are defined as vocabulary of drawings that can be drawn by the user and identified by the system. In our implementation of the *Stone Soup*, a set of 13 objects was established and used to help the main character, Ana, to accomplish her tasks according to the development of the story. As illustrated in Fig. 3, the interactive objects are the "sun", which turns night into day; "campfire", "candle", "lighter", and "matches", which are used as sources of light during the night, but are also dangerous and can cause a wildfire; "rain", which can extinguish a wildfire; "axe", "sword", "knife", and "scissors", which can be used to free tied characters; and "stone", "carrot", and "broccoli", which are ingredients that can be used to cook a soup.

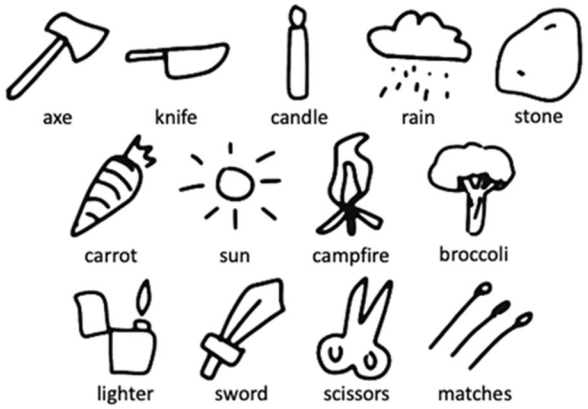

Fig. 3. Types of sketches (objects) that can be identified by the sketch recognition system in História Viva.

The branching structure for the interactive version of the *Stone Soup* is presented in Fig. 4. There are three main user interaction points, which are divided into the beginning, middle, and end of the story. For example, the first interaction takes place in the beginning of the story when Ana is walking through the forest. As she gets scared, she hides inside of a gourd and the user can help her get out of gourd by drawing a sharp object (an axe, knife, sword, or scissors). Although this interaction simply allows the story to move forward, the other interaction points produce different branches. For example, after getting out of the gourd, Ana finds herself lost in a dark forest and asks the user for help. The user can help her by drawing a sun, which will turn night into day and Ana will be able to find her path. However, if users decide to draw something different, like a candle or a campfire, Ana will end up starting a wildfire by mistake, which leads to a completely different storyline.

The creative process to enhance the original story of the *Stone Soup* with alternative branching paths took inspiration in common elements found in other Portuguese folktales. For example, in the folktale *Joy, Cliff and Pleasures* [26], Our Lady of Joy helps to extinguish a fire in the forest by making it rain. Inspired by this event, we included a branch in our story were the forest catches on fire (as result of the user drawing a campfire, matches, or a lighter). This event leads to the apparition of Our Lady of Joy, who helps Ana by putting out the fire. In this branch, Our Lady of Joy also guides Ana to a place where she can cook the soup. After arriving, a werewolf appears and offers food to Ana, which she can accept if the user draws ingredients, or not if the user draws a stone. If she accepts the werewolf's help, they cook together and, in the end, the werewolf transforms into a real man (End 3 in Fig. 4). If not, Our Lady of Joy returns and helps Ana to make the soup (End 4 in Fig. 4). The inclusion of the werewolf is also an inspiration from another Portuguese folktale: *The Werewolf from Fareja* [26], where a werewolf helps and gives food to a woman who lives in a village.

C. Visual Elements

The development of the visual elements for *História Viva* embraces different branches of design, such as branding, animation, and user interfaces. The logo, the frame-by-frame animations of the characters, the backgrounds, and the elements for the user interface must be cohesive so that they all promote *História Viva*'s identity.

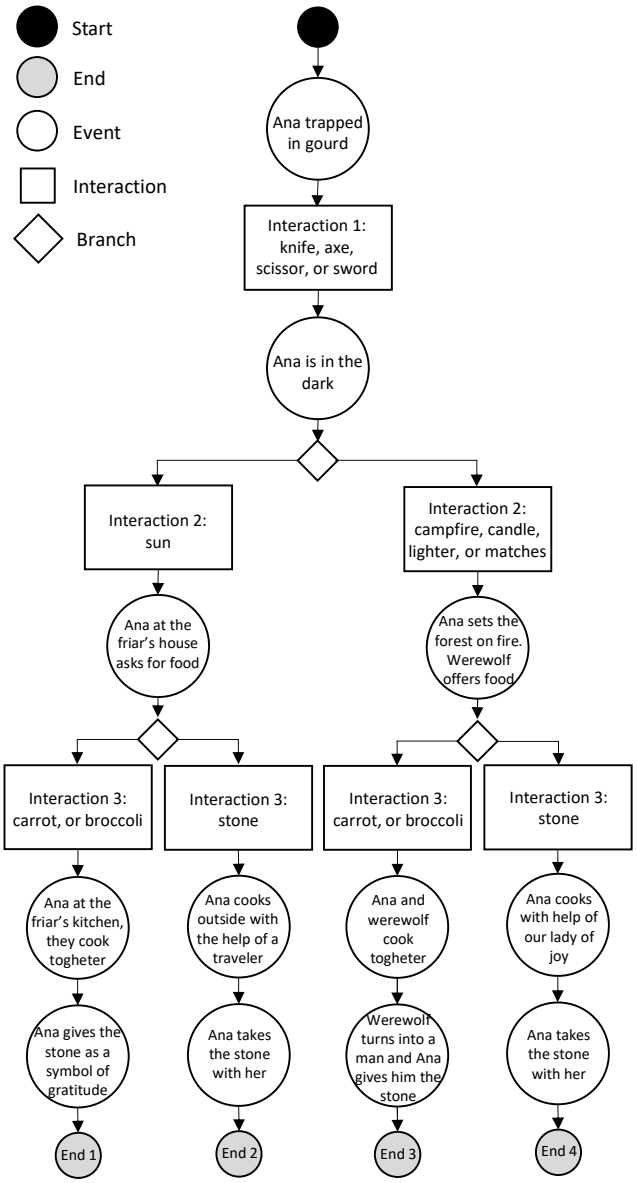

Fig. 4. Branching structure of the interactive version of the Stone Soup.

1) Logo

The development of *História Viva*'s logo (Fig. 5) was based on the creative proposal of Kapferer's identity prism [31]. As indicated in Fig. 5, the three main characteristics of the logo are: (1) the impact of the brand with the user, which correlates with a physical aspect of the object (the main inspiration behind using capitular letters was the font of old tale books); (2) the vertex of personality which connects the brand to emotions and qualities to which the user can relate is visible in the elements of the logo that represent movement and growth, which, in turn, relate to life; and (3) the business strategy, which is associated with *História Viva*'s brand and its relation with the market, can, for example, be seen in the use of vibrant colors and a clear font type that represents a system that relates to stories adapted for a contemporary marketplace.

2) Color

História Viva uses red as the primary color (Fig. 6). It is the most vibrant color and connected to a call to action. According to Bamz's study [32], the color red represents the age from 1 to 10 years old, being effervescent and spontaneous. Secondary colors are comprised of yellows, purples, and greens, which represent strength, magic, and friendship respectively [33]. This color palette presents the distinctive tones that were used to better harmonize the different needs of *História Viva* when the animation setting was designed.

Fig. 5. História Viva's logo.

Fig. 6. Color palette.

3) Typography

For headings, the MilkMan font was used with three different sizes to adapt to different situations [34]. The size numbering might seem big, but the font itself is small, needing a bigger size to balance it out as can be seen in Fig. 7. The three sizes are divided by 8, keeping the consistency with the 8-pixel grid. The rounded font is fun, dynamic, and childlike. For paragraphs, the Source Sans Pro family was used. This font was the first opened type developed by Adobe and it has a legible sans serif typeface capable of performing well in different interfaces [35]. Two different sizes and link options are used, depending on the scenario.

Fig. 7. Text styles.

4) Components

Buttons and other visual elements that were designed for the user interface are shown in Fig. 8. The prototype uses primary buttons and visual feedback cues. Other components, such as the buttons and arrows, are used in the interface of the system where users can navigate and select a story.

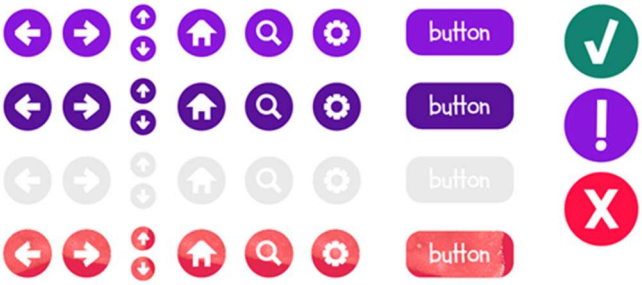

Fig. 8. Illustrations for buttons and feedback hints for the system.

5) Animation of Characters

For the visual representation of the narrative, *História Viva* uses a frame-by-frame animation technique to give the user the illusion of movement by creating small changes in the key frames. This type of animation is similar to the traditional hand-drawn animation, where each movement is drawn separately on a different sheet of paper [36]. It provides the designers with the opportunity to work freely with the desired artistic style for the animation.

The characters were illustrated using Adobe Illustrator, a digital tablet, and a pen. The illustration process for Ana is presented in Fig. 9. The animation frames were designed with four actions in mind: giving, idle, talking, and walking; except for the Lady of Joy, which fluctuates and blinks. Fig. 10 shows the frames for the walking animation of Ana.

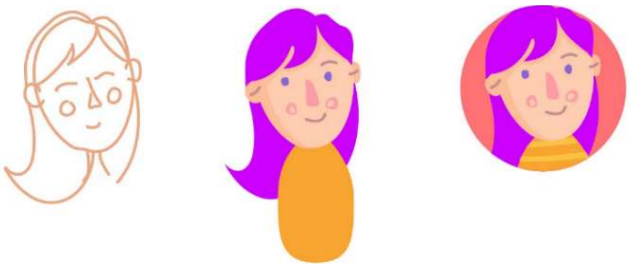

Fig. 9. The illustration process for the main character of the narrative.

Fig. 10. Frames of the walking animation for the main character of the narrative.

6) Backgrounds

The backgrounds for the scenes of the narrative were designed based on two main areas, namely the forest and the village. Each background has its own variations that had to be designed. For example, the forest has a day, night, and fire variations with its elements placed into them (Fig. 11). There is a different shade of dark when the fire is placed on the set. This provides support to the character's interactions and a better context within the development of the story.

The village is comprised of the friar's house, its surroundings, and a kitchen. It does not have the night version since Ana only goes there if the user draws a specific object that will turn night into day. Ana can cook the soup and interact with the friar inside or outside the house, depending on which interactions the user selects.

7) Scriptwriting and Voiceover

Based on the structure of the story and its branching points, a script was created in order to polish the details and to enrich the narrative. The script is available in a separated online document: http://www.icad.puc-rio.br/~logtell/sketch-based-is/script-stone-soup.pdf.

Considering the age range of *História Viva*'s target audience, dubbing the characters' dialogs is important to provide a more immersive experience. English was the first choice for the voices since it is the main language of this project, and it provides children from different cultural backgrounds the opportunity to use the system. Subtitles in Portuguese and other languages can also be displayed. The voiceover also serves as a guide to develop the characters' movements once they are in sync with the animation.

Fig. 11. Forest background variantions.

For the dubbing process, the sentences of each character were recorded separately. The audio files were then edited using Adobe Audition and saved in a mp3 file format to be used in the prototype.

D. Prototype

A prototype is a model of the product used to test an idea. It provides the designer with a very efficient and cost-effective way to get essential feedback to validate the product and its usability [37]. For the prototype, two systems were developed: (1) a dramatization system to display the animation of the narrative in a desktop computer; and (2) an interaction app for mobile devices to allow users to interact with the story by drawing objects. Both systems are illustrated in Fig. 12.

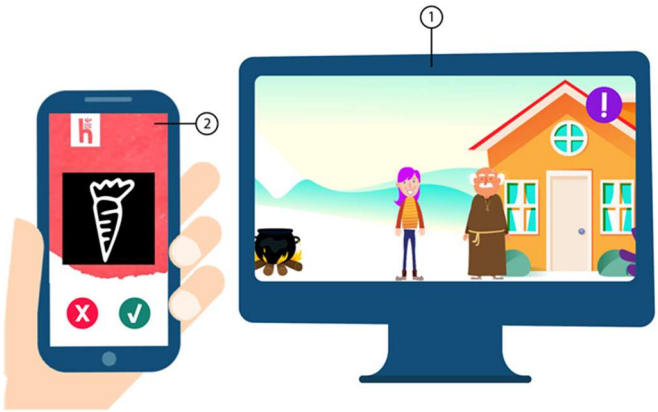

Fig. 12. The two components of História Viva: (1) the dramatization system that runs on a desktop computer; and (2) the interaction app that runs on mobile devices (smarthphones and tablet computers).

The architecture of *História Viva* is based on a client-server model, where the modules responsible for the generation and dramatization of the story are part of the server (the dramatization system) and the sketch-based interaction interface is a client (the interaction app). The interaction app is responsible for receiving the user's sketches, which are recognized by a Convolutional Neural Network classifier [38]. Once a sketch is recognized, an identifier of the sketch type is sent to the dramatization system through a local network message. The interface of the interaction app is then updated, and the story plot changes in the dramatization system according to the identified object. The dramatization system was implemented in Lua using the Löve 2D framework, and the interaction app was implemented in Java and runs on Android devices.

The sketch recognition module of *História Viva* uses deep learning, a field of machine learning that can create computational models composed of multiple processing layers to learn the representation of data [39]. Since deep learning requires training data, which can be difficult to obtain, a dataset of sketches was used. In order to train our Convolutional Neural Network classifier, we used the *Quick, Draw Dataset*, which is the largest available dataset of sketches, with over 50 million sketches of 345 different classes, such as clouds, cats, swords, cars, etc. [40]. It was created with drawings of 15 million players of a web game called *Quick, Draw!*. The dataset contains a huge number of illustrations of different objects, which allowed us to establish a good variety of possible drawings for every interaction point in the *Stone Soup* story. More technical details about the sketch recognition module of *História Viva* are presented in our previous work [41].

The interface for the prototype of *História Viva* was designed according to Norman's Six Principles of Interaction Design [42], which is based on human-centered design and focus on human needs, capabilities, and behaviors. The principles used in our prototype are:

1. Visibility: users need to have a clear view of the options that they have for interaction. As illustrated in Fig. 13, the system has 3 main areas related to user interaction: (1) interaction cue area, where a symbol of attention will be displayed when the user needs to interact (which is complemented by voice clues from the story characters); (2) drawing area, which is displayed in black to give the user higher contrast with the background and the sketch; and (3) send and clear buttons, which occupy a large are on the screen of the interaction app and are suitable for children use.
2. Feedback: users need an indication that their interactions have caused reactions on the system. In the dramatization system, when the user arrives at an interaction point, the characters will guide the interaction and a visual cue will be displayed (Fig. 13, item 1). In the interaction app, the black area displays the drawing made by the user in real-time (Fig. 13, item 2). Once the user activates the send button (Fig. 13, item 3), a message will inform the user the type of object that was identified and story characters will react to the object introduced into the story. If the system does not recognize the object, the characters repeat the interaction request.
3. Constraints: the interface must display only the necessary information and interaction options. Therefore, in the interaction app, *História Viva* centralizes the user focus on a black square, where they can interact with a limited space to focus on their actions (Fig. 13, item 2). As this space is centralized, the user can use their right or left hand to draw, making it possible to have a left- and right-handed experience. The list of objects that can be draw is vast, but the story characters always suggest what the user can draw at the interaction points, so the list of possible drawing becomes limited, and users can focus on relevant objects.
4. Mapping: there must be a relationship between controls and their actions. As described in Section III – B, the *Stone Soup* story supports 13 types of objects that can be sketched by users, which have their effects directly related to the object type and are explained by the clues given by characters during interaction points. In the interaction app, both buttons present an accent color and a related symbol: the green color and the check mean that the drawing is accepted, and the red color with an X symbol clears the user sketch.
5. Consistency: maintaining the consistency helps the user to recognize patterns, which can improve the learning curve. For *História Viva*, a base for the visual elements was developed with the intention of providing a consistent user interface (Section III – C). For the interaction, users can sketch objects in their own style, but they are translated into a set of elements that were designed with the visual consistency in mind.
6. Affordance: the system must provide users with clues on the usage of its elements. In the interaction app, the black square represents the space in which the children must draw, which resembles a blackboard. Also, as the story moves, the characters guide the user and provide clue about what can be draw at each interaction point. For example, when a werewolf approaches Ana, offering to help her by giving her ingredients to the *Stone Soup*, Ana thinks out loud, giving a hint for the user to draw a carrot to accept the stranger's ingredients, or a stone, to make the soup with just a stone.

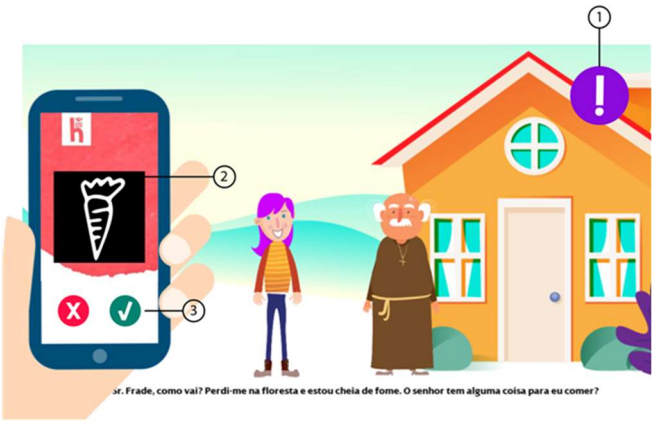

Fig. 13. Main interaction areas: (1) interaction cue; (2) drawing area; and (3) send and clear buttons.

IV. Usability Testing

In order to evaluate the usability of *História Viva*, we conducted a user study with five children, aged 6 to 11 years old, who participated in the test with the guidance of a parent/guardian. The main goals of this study are to: (1) evaluate the children's interactions by drawing; (2) evaluate the usability of the prototype by observation and think aloud; and (3) measure the user experience by applying the System Usability Scale (SUS) questionnaire. The participants comprised two 11-year-old boys, and three girls: nine, eight and six years old. None of the children were aware of the *Stone Soup* tale before testing our system.

The study was conducted remotely due to the COVID-19 pandemic and the test was divided into three phases: (1) the setup, where the parents' help was essential for the installation of the system; (2) the usability test, where children were asked to freely interact with the story until the completion of at least one storyline; and (3) the questionnaire and interview, where children and parents were invited to answer an adapted version of the SUS questionnaire designed for children [43]. During the test, children were asked to think aloud and express their impressions, feelings, doubts, and opinions.

The participation of the parents was essential for the test. They act as moderators, helping the children when necessary, and asking them to say what they were thinking out loud while performing the tasks. Parents were also responsible for recording the sessions, showing children reactions, the interaction app, and the results in the dramatization screen. The parents received the instructions by email and had an online meeting with the researcher before the test, where the purpose of the test and the parent's role were explained.

After finishing the story, children were invited and guided by the parents to answer the SUS questionnaire and to express their impressions about the experience. On average, each session lasted 15 minutes, including the time necessary to finish the story, to complete the questionnaire, and to collect the child's impressions.

A. *Qualitative Results*

The video recordings of the sessions provided qualitative data to be analyzed in order to frame the insights, map the user's pain points, and the usability issues. The next subsections report the experience of each child, which are divided into: (1) observations made by the researcher while watching the child using the system; (2) comments made by the child and/or the parent during or after the test; and (3) possible pain points mapped by the researcher.

1) User 1 (6 years old girl)

Observations: The space for the drawings was not enough and she exceeded the area when drawing a carrot, which caused the system to not recognize the object every time (Fig. 14). She liked the experience and even played it twice. The hardest part was getting the instructions with the carrot right, but it was also the part that she liked best. During the story, she wanted to draw more ingredients to the stone soup. There was a point where she double-clicked on the submit button, which made the system go into unplanned directions. She really liked the interaction with drawings and how that relates to the animation.

Comments: Her dad liked the fact that the story has different outcomes. Her dad did not like that the story was narrated in English, but the daughter forced him to keep the audio on. Her dad works in technology and his technical point of view is that he loved the concept of drawing on the phone and viewing the results on the computer, but he realized a few limitations related to the sketch recognition, such as an X symbol being identified as a knife.

Pain points: The story being narrated in English. The drawing space is too small, which may force the user to exceed the space and cause the system to not recognize the object.

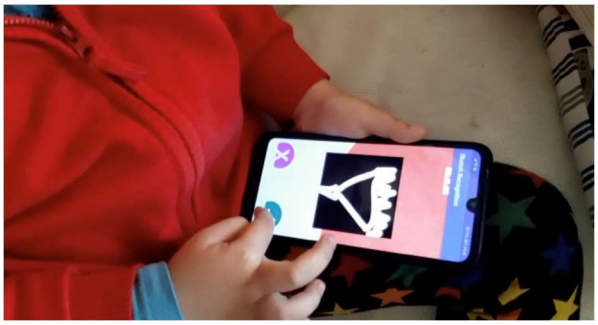

Fig. 14. User 1 drawing a carrot.

2) User 2 (8 years old girl)

Observations: During the first drawing, she sketched and waited for the system to recognize the object (without pressing the submit button). Her dad helped her to press the submit button. When the friar asked her if he should help Ana, she drew a check mark. She did manage to end the story, which means that the system responded accordingly with her interactions and the story progressed as expected.

Comments: She really liked the story and its development, but one of her frustrations was that the story should contain more "levels". She would like to play it again but wishes that the story would have more locations and characters.

Pain points: A carrot was identified as a candle (Fig. 15). The story is too short; it needs more characters and different scenarios.

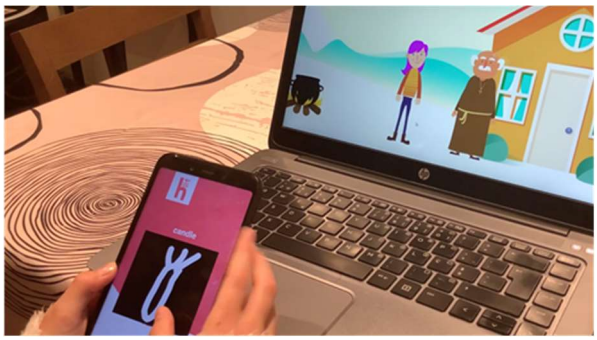

Fig. 15. User 2 tried to draw a carrot, but it was identified as a candle.

3) User 3 (11 years old boy)

Observations: It takes a while for him to understand that the drawings are affecting the story. When this happens, the user's impulse is to click on submit button several times, which can cause the system to move the story to unpredicted directions. He drew very careful and was attentive to details. When the story finished, nothing happened.

Comments: He thought the story was well constructed and "very cool", and that the animations and the overall design was well done. He liked to use the system and would like to use it again. He got a little bit of frustration when the system

did not recognize the carrot the first time. The black drawing area was adequate and there was nothing that he would have changed.

Pain points: Double-clicking on the submit button several times can cause unexpected effects in the storyline. Failures in the identification of the user's drawing cause frustration.

4) User 4 (11 years old boy)

Observations: When reaching the first interaction point, he waited for Ana to repeat the interaction instructions before starting to draw. He drew very carefully, but also clicked the submit button several time (Fig. 16), causing the same situation that occurred with User 3. Because of the repetitive click on the submit button, there were even more problems with the dramatization: the main character disappeared, but the user could still hear her voice; drawing a sun caused the forest to catch on fire, but that was only supposed to happen if the user drew matches or a fire.

Comments: The story was interesting and what he liked the most was the plot and helping the girl to make a soup. His least favorite thing was that, sometimes, the system did not recognize his drawings. He would play again once there are other possible drawings available. As a suggestion, he would like to create different types of soups by drawing the ingredients.

Pain points: Clicking several times on the submit button can cause unexpected problems with the dramatization, which can create frustration in users.

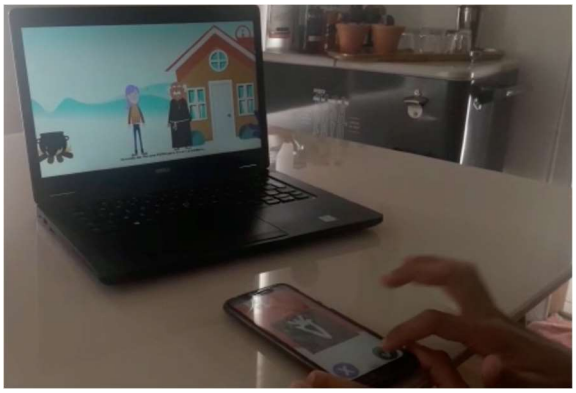

Fig. 16. User 4 clicking several times in the submit button.

5) User 5 (9 years old girl)

Observations: The experience was smooth as the system recognized all her drawings (Fig. 17), and she managed to finish the storyline as expected. She drew clearly and used most of the space in the drawing area.

Comments: Her first observation was that the colors were nice. She would like to play more and would purchase this interactive storytelling system. She really liked to help Ana in the various situations, such as when she was trapped in the gourd. She would love to play it again and she would also like to see new characters.

Pain points: There is a need for a restart button at the end of story.

B. Quantitative Results

Fig. 18 summarizes the quantitative results of the SUS questionnaire. The average SUS score was 88.5, which, according to SUS scale [44], indicates that the usability of the system is "excellent".

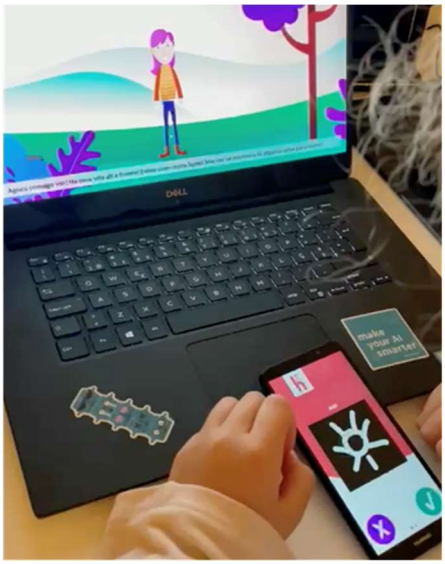

Fig. 17. User 5 drew a sun, which was correctly identified by the system.

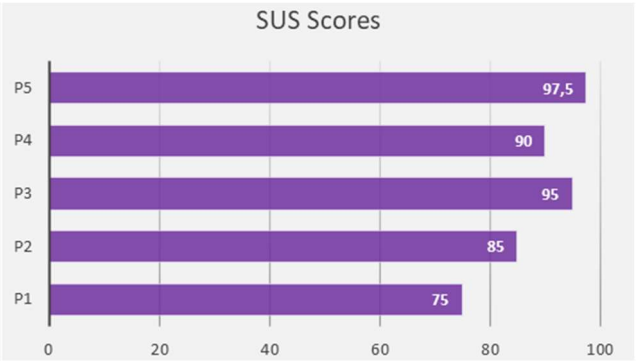

Fig. 18. Scores of SUS questionnaire.

V. Concluding Remarks

Folktales are part of the culture that is passed down from generation to generation. With the development of new technologies, it becomes important to adapt folk storytelling according to the current trends, especially when children from today's generation are digitally fluent and attracted by the use of technology in their everyday lives. In the current globalized world, where stories are presented in digital formats, children may know more about stories shared by large corporations, such as Disney, than folktales from their local culture.

In this work, we presented and evaluated an interactive storytelling system that allows users to interact with folktales by drawing objects on mobile devices (smartphones and tablets). Overall, *História Viva* was well-received and the comments from children and parents that participated in our experiment were very positive, and the children were very receptive and entertained by the experience. The sketch-based interactions were comfortable to perform, and the drawing experience surprised the users when they notice that the drawings were affecting the story. All children said that they would like to play the story more times. Frustrations were mostly related to the lack of feedback and misinterpretations of the drawings. The results and observations from the usability test were essential for us to identify the main points for improvement in our prototype, and certainty are valuable for future projects on sketch-based interactive storytelling.

Due to the COVID-19 pandemic, the usability test needed to be conducted remotely, which demanded extra effort, help

from parents, and also restricted the use of some features of our system, such as its capacity to create immersive experiences by projecting the animation into the walls of a room, and its ability to handle multi-user interactions (multiple mobile devices that can be used at the same time for cooperative interactions). Therefore, as future work, we intend to conduct more user studies to evaluate the immersive and collaboration features of *História Viva*.

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