

ShadowStory: Creative and Collaborative Digital Storytelling Inspired by Cultural Heritage

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ABSTRACT

With the fast economic growth and urbanization of many developing countries come concerns that their children now have fewer opportunities to express creativity and develop collaboration skills, or to experience their local cultural heritage. We propose to address these concerns by creating technologies inspired by traditional arts, and allowing children to create and collaborate through playing with them. ShadowStory is our first attempt in this direction, a digital storytelling system inspired by traditional Chinese shadow puppetry. We present the design and implementation of ShadowStory and a 7-day field trial in a primary school. Findings illustrated that ShadowStory promoted creativity, collaboration, and intimacy with traditional culture among children, as well as interleaved children's digital and physical playing experience.

Author Keywords

Storytelling, children, creativity, collaboration, cultural heritage, shadow puppet.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design, Human Factors.

INTRODUCTION

During the recent years, the developing world has attracted much attention in HCI research, resulting in various technologies created specifically for it, such as to facilitate education [13, 26], to assist illiterate populations [18, 24], or provide service in rural areas [16, 17]. Such efforts could potentially enhance the wellbeing of such developing societies, and reduce the technology gap between them and the rest of the world.

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However, the other side of the coin, which has only recently started to draw attention, is that the fast economic growth and urbanization in some of these developing countries may themselves create new social problems that did not exist before. The weakening of community ties, the overindulgence in information technology, and the loss of traditional values are just a few to mention. As the newest generation of the society, such new problems often can be most easily observed in children. For example, in today's China, especially urban regions, on the one hand children enjoy more attention, comfort, and education than the previous generations ever did, and receive ever higher expectations from their family; while on the other hand they were also reported to be more isolated, more self-centered, and lack interpersonal skills compared to their predecessors [11]. In addition, children's entertainment activities lean more and more towards electronic toys and computer games, most of which tend to simply entertain them rather than encourage self-initiated creativity as some more traditional ways of playing do [6]. These problems may have serious impacts on children's development.

Besides, as globalization penetrates the developing countries both economically and culturally, much of their local traditional culture and arts, which had been carried on for many generations, have now become less known to their younger generations, or even on the brink of disappearing. Such intangible cultural heritage has been identified by UNESCO (United Nations Educational, Scientific and Cultural Organization) as "provides them a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity" [25]. How to preserve it and pass it onto future generations in the context of vast modernization is yet another challenge for the developing world.

Interestingly, what may be lacking in today's environment for children, namely space for creativity and collaboration, are indeed abundant in many traditional art forms. Taking China as an example, ancient arts such as Beijing opera or shadow puppetry combine various aspects of artistic creations (visual, musical, theatrical, etc.) and require several artists to closely work together. Thus, letting

children playfully involve in such art activities could perhaps become a potential opportunity to promote creativity and collaboration among them, while at the same time increase their intimacy with their own cultural heritage. However, given the decreasing number of traditional artists fewer opportunities are now available for children to experience these arts first-hand. These arts often also require intricate skills and significant time investment to learn, creating a higher entry barrier for children to involve themselves, compared to modern entertainment technologies. Immersing children in traditional arts is not as straightforward as we may hope.

Motivated by such challenges, we propose a hybrid approach to combine the key elements and appeals of traditional arts with the convenience and immediacy of interactive technologies. We aim to create playful interactive systems for children which are inspired by traditional art forms. The goal is to capture and emulate certain experience, style, process, and skill of the original art, while at the same time significantly lower the entry barrier and higher the freedom of creation through digital technology.

For a first exploration in this direction, we take shadow puppetry, a Chinese traditional art, as our inspiration. Officially listed as a state-level intangible cultural heritage, Chinese shadow puppetry (Figure 1a) is an ancient theatre art with a reported history of over two thousand years [7]. Differing from most other forms of puppets, shadow puppets are flat articulated figures made of semi-transparent leather. These are manipulated behind and against a back-illuminated screen using a set of sticks. Sceneries, or backdrops, also made of leather, are attached to the screen. Story plots are depicted through puppet movements, narrations and conversations, as well as librettos sung by the performers, similar to those heard in Chinese operas. The special mechanism of shadow puppets results in highly unique visual styles and movement languages. Several schools of shadow puppetry developed in China, and variations of it could be found in more than 20 countries. A rich repertoire of plays and puppet designs was accumulated throughout the generations, covering traditional myth, legend, history etc. However, once a very popular folk entertainment throughout China, shadow puppetry is now becoming an endangered art. Dominance of modern entertainments, high skills required in making and performing the puppets, and lack of formal curriculum were all contributing factors. We chose shadow puppetry as the theme of our system for its playful nature, unique art style, richness in creativity and expression, deep root in traditional culture, but also its endangered status.

Inspired by this, we created ShadowStory (Figure 1b), a digital storytelling system that allows children to freely create digital puppets and perform stories using them, in a style consistent with traditional shadow puppetry. We offer simplified operations and intuitive interfaces through digital technologies; while still conserve key processes and

elements of physical shadow puppetry. Digital puppets are created through pen and tablet input, using virtual tools similar to the tools for creating physical shadow puppets. Public performance of stories can be held on a projected screen and controlled by handheld orientation sensors, again emulating the atmosphere of traditional shadow puppetry plays.



Figure 1. (a) Chinese shadow puppetry. (Image by Alex Yu)
(b) Three children playing with ShadowStory.

In the rest of the paper, we first overview related research, followed by an initial investigation of current children’s play in urban China, and a summary of key elements in Chinese shadow puppetry. After describing the ShadowStory system in detail, we report a 7-day field trial of it in a primary school, with findings regarding how it promoted creativity, collaboration, and intimacy with traditional culture, as well as interesting interactions between physical and digital play.

RELATED WORK

Many researchers attempted to facilitate children’s creativity and/or collaboration through technology. For example, I/O Brush [21] is a “magic” brush that allows children to pick up colors, textures and motions from everyday objects and use them to draw creatively; MEDIATE [15] uses visual, auditory, and vibrotactile stimuli to inspire creativity by children with autism; Tangible Flags [8] is a mobile technology to allow young children to collaboratively create presentations during field trips; and WHAT-IF [14] combines several handheld devices to create a larger information viewing surface and therefore promote collaboration among them.

Among these attempts, of particular similarity to our work are those focusing on children's storytelling activities. Fantasy storytelling play was found essential for children's development [6, 20]. In addition to accommodating almost unlimited creative imagination, fantasy storytelling offers a space for children to take different roles in their play, allowing various group interactions and collaborations to emerge and potentially be transferred into the real life. Numerous digital systems were created to support such fantasy storytelling. Many aimed to interleave digital and physical worlds. For example, StoryMat [19] and Rosebud [12] both included instrumented physical toys as index and trigger for narrated stories; Video Puppetry [2] used an overhead camera to track performances of paper puppets and translate them into digital stories; while to offer more space for creativity, both Pogo [9] and Telltable [4] allowed children to use photography to capture real-world objects as elements of their digital stories. TellTable [4] also leveraged the affordances of multi-touch tabletops to allow several children to work both collaboratively and independently. Other systems, such as StoryTable [5] and KidPad [3] went further and explicitly encourage collaboration by introducing actions that must be performed jointly by several children.

The preservation and promotion of cultural heritage has also attracted attention of many HCI researchers. For example, Ruffaldi et al. [22] created an information landscape system for digitally presenting cultural heritage content as immersive visualizations. Multicultural Videos [10] is an interactive online museum for artists around the world to share their cultural heritage. And targeting at children in particular, Amicis et al. [1] used playful virtual environments and video games to promote the learning of history and cultural heritage among them.

Despite the rich literature listed above, to our knowledge we are the first to explore incorporating components of creativity, collaboration, and cultural heritage in the same system to promote them among children. The effectiveness of such combined approach will be demonstrated through this paper.

INITIAL INVESTIGATION ON CHILDREN'S PLAY

To further investigate the current situation and issues in children's daily play in urban China, especially relatively developed regions, we conducted informal interviews in a public primary school in Beijing. Two teachers and five pupils (aged 7-8) from the school participated. Both teachers were directors of grade-2 classes (aged 7-8), one for a class of 37 day pupils, and the other for a class of 36 boarders. The former had 4 years of teaching experience, and the latter had over 20 years of teaching experience. The interview questions focused on the children's playing habits, creativity and collaboration, as well as their familiarity with traditional culture. In addition, we observed pupils playing in the school during breaks, which helped verify the findings from the interviews.

According to the teachers' experience, there were two main issues in these children's daily play. Firstly, the children did not seem to have many opportunities for creative play. The most common game among boys was "One two three, freeze", a simple chasing game, and among girls it was "knitting flower baskets", a simple hopping game. Fantasy role playing were not commonly observed. Secondly, the children's collaboration skills tended to be lower than those of the same age several years ago. For example, when taught to play "throwing the bean bag", a dodgeball-style game between two teams, they required help from the teacher to coordinate the turn-taking between teams. Many children would simply follow the teacher's actions instead of coordinating with other teammates. These comments were confirmed through our observation of the children playing. The teachers further commented that these issues had become more apparent in the recent years, but had not yet drawn enough attention.

Three main reasons may have contributed to these issues. Firstly, much of these children's playing time was now dominated by electronic entertainment. The interviews with the pupils revealed that their forms of entertainment at home were mainly television watching, electronic toys, and computer games. For example, two boys indulged in Happy Farm (www.kaixin001.com), a popular online social game targeted mainly at young adult professionals. Such virtual content not only reduced the children's direct interaction with others, but might also pre-shape their ways of thinking and playing in the real world. Secondly, the lower birthrate today means that compared to previous generations these children had fewer playmates at home who were from the same family and of similar age. And lastly, the high expectation by Chinese parents today often resulted in many children attending various extracurricular tutorials such as music, art, or foreign languages, reducing their time to play freely. All these factors may have resulted in a decrease in children's creativity and collaboration skills.

In addition, despite the school's efforts on education about Chinese traditional arts, most pupils were not particularly familiar with them. This was again partly due to the fact the children had much of their entertainment through cartoons and computer games which were mostly westernized, whereas local arts were no longer a regular part of their daily life. In the case of shadow puppetry in particular, only one out of the 36 children in a class we asked had experienced it in person with her parents, while the majority of the other children had only seen it on television and did not know much about it.

This investigation confirmed our concerns about today's Chinese children's creativity, collaboration, and knowledge of cultural heritage. This led to our attempt to develop a digital storytelling system that aim at promoting all these three aspects among children, inspired by the ancient Chinese art of shadow puppetry and allowing children to freely and intuitively express their creativity in a collaborative setting.

ELEMENTS OF SHADOW PUPPETRY

In order to extract key elements of shadow puppetry that might be appealing to children and applicable to our system, we studied 20 classic Chinese shadow puppet plays, which involved reading scripts and watching videos of the plays, watching media interviews with the shadow puppetry artists, as well as learning to manipulate the shadow puppets ourselves. As a result, below we draw a summary of their production process, control mechanism, art style, etc.

Design and Performance Stages

Like other puppetry arts or indeed theatre arts in general, the production of a shadow puppet play consists of a design (or composition) stage and a performance stage. In the design stage, the plot of the play needs to be determined, and all characters, backdrops, music, and lyrics created or composed. The play plots most often center around traditional Chinese myths or legends that are familiar to most local audiences. Famous characters such as the Monkey King (Figure 2c) are depicted frequently, as they are in other forms of Chinese arts. In the performance stage, the performers manipulate articulated characters behind the back-illuminated screen while narrating, conversing, or singing librettos for the characters. The combination of puppetry, lighting, music, and storytelling creates a compelling experience for the audience.

Creating Puppets

Shadow puppets are made of donkey or cow leather. Such leather is light and semi-transparent, making it ideal for the back illumination used in the play to penetrate. First the outlines of the puppet parts are carved out using a pricker knife, and inner patterns carved using a set of graver knives (Figure 2a). Then the parts are painted in bright colors using special brushes, resulting in lively tints when back-illuminated (Figure 2b). Finally the parts are riveted or bound together to create the articulated puppet (Figure 2c). Making shadow puppets is a highly skilled handcraft, and a typical puppet can take an experienced artist two or three days to make. Each single puppet is unique and bears strong signature of the region and the artist.

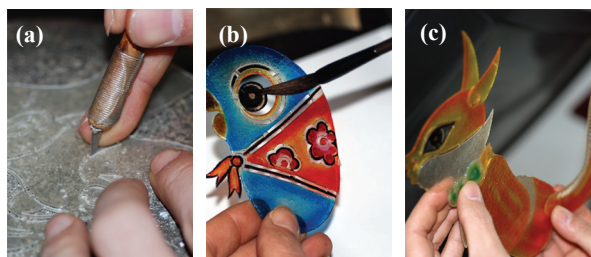


Figure 2. Creating shadow puppets.
(a) Carving. (b) Painting. (c) Assembling.

Colors and Patterns

Similar to in Beijing operas, colors are used to represent personalities of the characters, e.g., black represents justice, red represent loyalty, and yellow represents duplicity. Meanwhile, various symbolic decorative patterns such as flowers, animals, and Chinese scripts are also utilized to illustrate the identity and traits of the character.



Figure 3. Shadow puppets with various colors and patterns.

Components and Manipulation

A shadow puppet is typically composed of eleven or twelve components: head, upper body, lower body (or two thighs), two calves, two upper arms, two forearms and two hands (Figure 4a). The performer manipulates the puppet using three sticks (Figure 4b). One stick is connected to the neck joint between the head and the upper body, controlling the basic movements of the character such as walking, sitting, standing up, jumping, or flying. The other two sticks are connected to the two hands, controlling the movement of the arms and hand gestures. Combining the manipulation with all three sticks, a skilled performer can make the character do a large variety of actions.

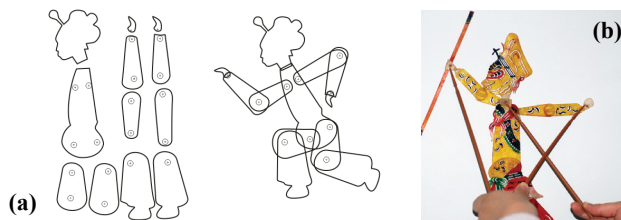


Figure 4. (a) Components of a typical shadow puppet.
(b) Manipulating puppets with sticks.

Singing, Narration and Music

Besides the visual elements, singing, narration, and accompanying music also play essential roles in the performance. Bearing many similarities to those found in various forms of Chinese operas, these are not only to help the audience understand the story, to add to the atmosphere and effect, but also to synchronize the puppet movements with rhythms.

Collaboration in Performance

Collaboration is the key in shadow puppet performances. Several performers, each controlling one or several characters, need to work in precise coordination, especially for interactive actions such as shaking hands, hugging, fighting, etc. Sometimes it may also require more than one performer to control a single complex character.

As illustrated above, shadow puppetry is a composite art that combines painting, sculpting, music, playwriting, and performance, which are often mastered by the same artists. This makes shadow puppetry the fascinating art it is, but also creates very high entry barrier for would-be artists. We believe the attractiveness of shadow puppetry would make it an ideal metaphor for our system. However, in applying

these elements to our system design we need devise ways to not only allow children to achieve the similar rich expressiveness, but at the same time significantly lower the complexity and skill requirement of the process, and create an environment for children to design and perform in ways that are intuitive, efficient, and familiar to them.

SHADOWSTORY: DESIGN AND IMPLEMENTATION

Based on such understanding and consideration, we designed ShadowStory, a storytelling system that allows children to use a Tablet PC to create articulated digital characters and other props in the style of shadow puppets and with similar (virtual) tools; and perform live stories together on a projection screen by controlling the characters with simple body movements through wireless handheld orientation sensors. We employed an iterative design process. An initial prototype was trialed with 3 children in a primary school. Led by observations during this initial trial, we simplified the workflow, improved usability, and ensured robustness in the final system presented below.

ShadowStory includes two interaction modes: “Design” mode, in which story elements can be created; and “Perform” mode, in which stories can be performed in public. There is also a video library of real shadow puppet plays that is available for the children to watch at any time.

Design Mode

In the Design mode, children can use a Tablet PC with pen input to create three types of story elements: characters, props, and backdrops.

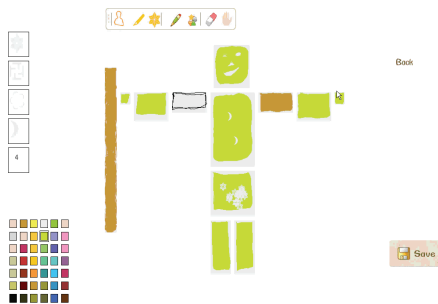


Figure 5. Interface of “Design” mode (for creating characters).

To start creating a character, the system provides an articulated template consisting of 11 required body parts: head, chest, belly, left/right forearm, left/right upper arm, left/right hand and left/right leg; and one optional item held by the character (Figure 5). Children can create these parts individually by using a “knife” tool and a “brush” tool to carve or paint on them. Similar to the physical knives used in creating real shadow puppets, two types of “knives” are provided: one for carving the outline, and one for carving inner patterns. The brush tool allows children to paint in various colors and thicknesses. In addition, several “stamp” tools allow children to directly imprint common traditional decorative patterns without efforts, such as peony, longevity, and crescents. After all individual parts are created, children can save the completed articulated character to the library to

be used in performance. Such articulated characters can potentially display an abundance of actions.

To create props, which are all unarticulated, the system provides an empty grey background representing a piece of leather as used by puppet artists, on which children can use the same knife and brush tools to create simple movable objects such as animals. Similarly they can create backdrops which remain static during performance.

In addition to elements created by the children, the system also includes a library of digitized traditional shadow puppetry characters, props, and backdrops, the content of which are generally familiar to Chinese children. These can be directly used by the children in their performance, or serve as inspiring material for their own creations.

Auditory elements such as singing, narration, or music are not included in the Design mode. These are slightly more challenging for the children to compose ahead, therefore are left for the children to create in situ during the performance, should they choose to do so.

Performance Mode

After all story elements have been created, children can switch to Performance mode to act out their stories. Firstly, they should arrange the stage with elements according to their stories. They can bring in saved story elements into stage by selecting from the characters, props, or backgrounds library. Every character or prop added into the stage is automatically assigned to a pair of handheld sensors, while a backdrop brought into the stage replaces the previous one. Once the stage is set up, children can press the “perform” button to activate the handheld sensors and perform their stories, as shown in Figure 6. The performing interface is also displayed on a projection screen visible to all performers and audiences, allowing them to engage with each other similar to in the case of real shadow puppet plays.

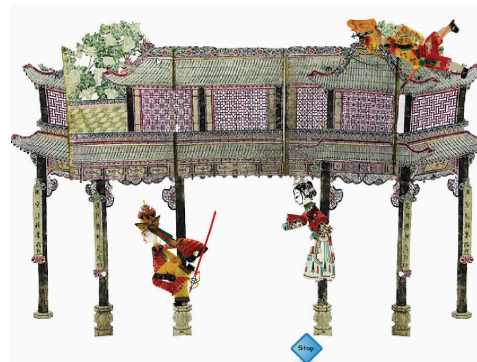


Figure 6. Interface of “Performance” mode.

As we described, manipulating a real shadow puppet requires highly skilled hand control and directly touching the puppet with sticks. To simplify the control mechanism in our system, and to free the children from standing next to the computer, we opted for using simple wireless handheld sensors instead. For each character, the controlling child holds a pair of 3D orientation sensors, one in each hand. Instead of direct manipulation on the puppet parts, the child

can move the character left, right, up, and down by tilting the first sensor in the corresponding direction. Tilting the second sensor leftwards or rightwards results in the character bending the body in the corresponding direction, as if bowing or looking up. Other joints of the character automatically move accordingly to match these main movements, e.g., the arms and legs swing naturally as the character walks. Similarly, the child can move and rotate a prop using a pair of sensors. Given that one child can only control one character or prop, almost all stories need to be performed by several children collaboratively.

Children can narrate, dub, or make any sound effects as they perform. When the story is over, they can press the Stop button to finish.

Implementation

The ShadowStory hardware includes a Tablet PC, a projector, and currently six wireless WiTilt v3.0 [27] orientation sensors manufactured by SparkFun (Figure 7b). The dimensions of the sensor are 2.20 x 2.81 x 0.73", convenient for children to hold in hands. Each sensor transmits pitch, yaw, and roll angles at 50Hz via Bluetooth to the Tablet PC. For each pair of sensors used by one child, the character or prop's vertical position is linearly mapped to the pitch of the first sensor; its horizontal position is linearly mapped to the roll of the first sensor; and its bending (for character) or rotation (for prop) angle is linearly mapped to the roll of the second sensor. Additional pairs of orientation sensors can be easily added to the system should they become necessary. The ShadowStory user interface was implemented in Flash, and the communication with sensors implemented in C++.



Figure 7. Hardware interface. (a) Playing with the hardware. (b) Handheld sensor (image from www.sparkfun.com).

FIELD TRIAL PROCEDURE

We conducted a field trial of ShadowStory in a primary school in Beijing for one and half weeks (7 school days) to explore how children would understand and play with it, and what interesting behaviors might emerge. The school has approximately 4000 pupils, including approximately 3600 day pupils and 400 boarders. The boarders have an activity class as a break between afternoon classes and supper.

We ran 7 trial sessions, one each day, with a grade-2 class of 36 boarders aged between 7 and 9. Each session lasted 40 minutes during their activity class. In total 14 children played with ShadowStory, comprising 5 boys and 9 girls. They divided themselves into 4 groups voluntarily. On the

last day, the 4 groups gave public performances of their stories for the whole class of children.

During the sessions, one teacher (the director of the class) and three researchers were present. On the first day, before the session began, a researcher demonstrated the system usage to the children. Each group of children then practiced both the design and the performance mode with the Tablet PC and the handheld sensors for 10 minutes in total, with hands-on assistance from the researcher. Before trying performing their stories for the first time, children were again given 3 minutes to re-familiarize themselves with the handheld sensors. Most stories were rehearsed by the children through the performance mode the days before the public performance. Once the children have learned the system, the researchers and the teacher remained unobtrusive and merely observed the children's creation and performance processes. They only stepped in when occasionally children faced technical difficulties and requested assistance, such as helping rotate the screen of the Tablet PC.

We chose the classroom as the location for the field trial, firstly because it was a familiar environment that the children spent much of their day studying, playing, and socializing, so that they would behave naturally, and potentially interaction may emerge between ShadowStory and their other daily activities. Secondly, the children were already familiar and comfortable watching and using the projector installed in the classroom, which was used daily in lessons, removing the potential technology barrier. And lastly, classrooms are indeed among the main venues that we envision the system to be used in, therefore it is important to understand if it would fit within the physical, social, and organizational constraints of the classroom contexts without disrupting other activities.

Two video cameras were set up to record all activities around the Tablet PC and the projection screen respectively. All interactions on the computer, in both design and performance stages, were recorded using screen-capture software.

Throughout the period of the trials, we interviewed 10 children who played with ShadowStory, and in addition 6 children who did not but watched other children playing and performing using it. These semi-structured interviews took place in the classroom and focused on their impression of the system, sources of inspirations for plot, interactions with audience and other groups, etc.

We examined transcriptions of the interviews together with field observation notes and video recordings. Findings were organized into themes to explore commonalities and diversities in how the children played with ShadowStory.

EXPERIENCE WITH SHADOWSTORY

Children's impression of ShadowStory was unanimously positive. All the children who had played reported that they had enjoyed it very much, and those who did not play asked

for opportunities to play next time. Many requests were made for us to visit the school again with the system. The design tools were found intuitive to use. During the initial introduction and practice, the use of handheld sensors was quickly understood by the children, and after a few minutes they all became proficient in controlling characters this way.

Going beyond such general evaluation of the system itself, we will now report experience regarding the three aspects we aimed to promote through the system, namely creativity, collaboration, and intimacy with traditional culture, followed by a few additional observations between digital and physical play.

Creativity

Despite the relatively short time frame available, children created 6 unique stories, some with several variations, and in addition to using traditional elements provided by the system, created 4 characters, 3 “animals” (in the form of props), and 4 backdrops. Figure 8 illustrates a few of the stories and Figure 9 illustrates some new elements created. Table 1 summarizes the characteristics of these stories. Each story had a clear, albeit simple, storyline.



Figure 8. Stills from children's stories. (a) “Catching rabbit”. (b) “One day at home”.

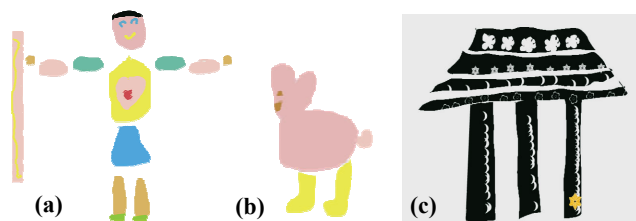


Figure 9. Story elements created by children. (a) Character. (b) Animal “rabbit”. (c) Backdrop (imprinted with traditional patterns).

As shown in the table, the story plots children created were inspired by a variety of sources. Apart from inspirations from traditional myth, which we will discuss in more detail later, life at home serves as another rich repertoire for inspirations, be it realistic daily life, or stories told by family members. Even more interesting was how they blended these two sources together. For example, in the “Catching rabbit” story (Figure 8a), the rabbit, which was created after the pet rabbit at one child’s home, was combined with traditional characters of a princess and Nezha the child deity to create a half-myth half-reality story. And in the “One day at home” story (Figure 8b), multiple

copies of the traditional Monkey King character were used as representations of one of the children himself and his playmates, to depict them playing together on a backdrop they painted to represent his home.

Story Title	Inspiration Source	Elements Used	Number of Performers
New journey to the west	Traditional myth	Traditional	4
Story of Pigsy	Traditional myth	Traditional	3
Catching rabbit	Pet rabbit at home	Traditional + Created	3
One day at home	Daily life	Traditional + Created	2
Horse training	Story told by grandparents	Traditional	2
Go to Mongolia	Family holiday plan	Traditional	3

Table 1. Summary of children's stories.

Another interesting aspect was how the children creatively defined new performance languages to overcome the constraints in the functionalities supported by the current system implementation. For example, one story required a monk to lie down and pretend to be ill, a movement not current supported. Instead, the children decided to make him stand still against a pillar, symbolizing the lying down action – a similar style of symbolic actions are often seen in Chinese operas. Another constraint in the system was that it did not support introducing new characters or backdrops during the performance. To overcome this, in the “Go to Mongolia” story, the ridge of an archway was used to symbolize a Mongolian tent for their similarity in shape, and when the character rode on a horse and moved to the tent, this symbolized that the scene had now changed to Mongolia. A second example was in an early version of the “Story of Pigsy”, where the same character was used to represent both a real and a fake Monkey King, and performed by the same boy.

In addition to these planned creations, we also observed improvisations in both the design and the performance stage. While characters were being created, many of them completely changed from what they were originally envisioned to be because of other children’s suggestions. And in most story performances, much flexibility existed in the plot, and many children preferred to freely perform what they felt was appropriate to happen under the story context. For example, in the “pretending to be ill” example we mentioned, both this action and its symbolic representation were indeed suggested by a fellow performer on the fly, in order for the monk to confuse an evil witch. This type of improvisation is also commonly observed in children’s fantasy play [23].

These rich creative behaviors assured us that creativity is inherent in children’s minds. ShadowStory provided an opportunity for them to more easily express such creativity,

and at the same time inspired by the rich repertoire of traditional arts.

Collaboration

Collaboration was inherent in the performance stage of ShadowStory, requiring multiple children to coordinate their characters to perform a coherent story. Children often explicitly talked to each other during the performance to coordinate, especially to align their characters (“*Don’t move. Let’s play over there!*”, “*Wait for me! You should walk right.*”) and to plan next steps (“*Let’s play on the sky, and then I will get down.*”). Some children might voluntarily take the role or the “director” to coordinate all performers during the performance. Collaboration was also essential in the design stage. Most of the designs and plots went through considerable evolution through group discussion and included contribution from each member. Children often helped each other when they had difficulties doing certain actions.



Figure 10. Collaboration during: (a) Design. (b) Performance.

Besides the above more general collaborative behaviors, there were several specific aspects we would like to detail:

Turn-taking

Although in the performance stage ShadowStory requires several children to act simultaneously, in the design stage the Tablet PC only supports one child to use at a time. This differs from multi-touch tabletop systems that allow multiple children to create independently [4], and mandates turn-taking between children.

Somewhat contrary to the findings in our initial investigation, children were very conscious of coordinating turns fairly between themselves when using ShadowStory to create story elements. We did not observe cases of one or a few children dominating the system, as was reported with some other systems [4]. Instead, many children voluntarily yielded the turn to others when they finished certain steps, such as when switching from carving to painting. This was particularly common between close friends. In other cases, the order of turns needed to be explicitly determined beforehand, sometimes using simple rules such as from the youngest to the oldest (it is customary in China for older children to yield to younger ones to show caring), and at other times using “fairer” methods such as finger-guessing games to decide when consensus could not be reached. When “unfair” turn-taking emerged, some member of the group would usually point it out and the problem was corrected. We suspect such slight difference in children’s turn-taking behaviors might be attributed to cultural

differences, as Asian cultures tend to emphasize more on courtesy and avoid aggressiveness, and this is solidified in the early education of children.

Assigning Roles

Given the stronger emphasis on public performance in ShadowStory as compared to some other storytelling systems, children attached more value on choosing which roles (characters) they perform in the stories, as these were considered projections of themselves. Personal feelings about the characters were the main reason of choices, for example many girls would choose pretty female characters or cute child/animal characters, while powerful male characters were preferred by boys. When conflict happened, they negotiated alternatives (“*I have chosen this one already. You can take the other girl, she’s pretty, too.*”); and when some children could not make their mind, other members of the group gave suggestions. Sometimes a satisfying role assignment was even the driving factor of the plot development itself. For example, in the case of “*Story of Pigsy*”, the boy who had the original idea envisioned a simple scene of Pigsy (himself) resting in the park. However when asked by other children what would be roles for them, the plot evolved and enriched to become a fight between Pigsy and a witch to feature all group members. With the only girl in the group refusing to take the role of the witch, the plot changed again to finally become a fight between Pigsy, Sandy, and Monkey King, all of which were positive characters in the original myth.

Although roles were usually explicitly assigned beforehand, sometimes the assignment may evolve during performance: one girl yielded her role of Nezha halfway in the performance because another girl thought it was cuter. Sometimes role assignments were even exchanged between different groups of children. On the final performance day, the girl who originally played Sandy in the “*Story of Pigsy*” was replaced by a boy who was not part of the group, because the other two members (boys) thought it would be more fun to play with a boy in fighting scenes. This girl instead joined another boy in the “*Horse training*” story and became a new character in the story.

Interaction with Audience

On the final day, the entire class of children was present to watch the performances. We found that the performers and the audience were mutually influential to each other. While watching the performances, the audience often thought about stories they could tell themselves. More interestingly, children in the audience who were to perform themselves were often inspired by what they saw. Ideas in earlier stories were often alluded to in later ones. In other cases, the groups who were to perform next adjusted their acting according to the audience’s response: when the audience commented the story was too simple, later groups added new plots to their own stories.

Conversely, encouragement and acknowledgement from the audience were found effective for the performers to build self-confidence, especially for isolated children. There was

one boy who was often isolated by other children in class activities for being “weepy”. However he created an interesting story and eventually found a story partner. His performance was well received by the audience, and he started to engage more in group activities after the performance.

Given these rich collaborative behaviors observed, we feel we should be cautious about the simple conclusion of these children lacking collaboration skills. Compared to some existing games with relatively fixed rules that we mentioned, ShadowStory provided an open and creative environment that required various self-initiated collaborative behaviors but did not explicitly dictate how these should be achieved. We believe it was such opportunities that helped open up the children’s potential for collaboration.

Intimacy with Traditional Culture

As mentioned previously, few children in the class were familiar with traditional shadow puppetry before the field trial. In the beginning of the trial, we also provided real shadow puppets for the children. They showed a great deal of interest and immediately tried to play with them. However they soon discovered they could not master the control of the puppets, and started randomly pulling the limbs. Before long the puppets were broken and returned to us, and the interest diminished. This clearly illustrated how the high entry barrier prevented the children from becoming more intimate with such traditional arts despite their initial interest. In contrast, ShadowStory retained the inherent appeal of traditional arts, yet eliminated the initial barrier and allowed the children to immerse in a more holistic, if simulated, experience. Through playing with the system they gained knowledge of the complete process of creating and performing shadow puppets, and experienced some of the unique skills involved, e.g., the use of virtual carving knives was found particularly attractive to many children. And mostly importantly, they could enjoy a sense of achievement through their own new creations, which would be near impossible for them with the physical form of the art. Such positive experience of initial contact could serve as a good basis to attract them to further understand the art.

In addition to shadow puppetry itself, other elements of traditional culture were ubiquitously seen in children’s experience with ShadowStory. Some of these elements were already known to the children and contributed to their intimacy with the system. For example, the first two stories in Table 1 both originated from the traditional myth novel *“Journey to the West”* and featured the Monkey King and his companions. This was not only thanks to the beauty of such characters provided in the system library, but also due to the myth’s extreme popularity in China. Moreover, as shown earlier children re-appropriated these traditional characters to suit their own plots, or redefined their relationship to create new plots. Children also brought their own knowledge about tradition and history into the system.

For example, one boy’s grandparents told him stories about post-horses used for sending urgent mails in ancient China. He was fascinated by this, and created the *“Horse training”* story about catching and training wild horses to send messages for him.

Conversely, many traditional cultural elements were introduced to the children through the system and adopted by them. For example, the children particularly enjoyed using the “stamp” tool to imprint traditional patterns on many of their creations. Although they would need later education to be able to understand the symbolic meanings of these patterns, such initial impression might plant seeds in their minds for such pursuit in the future. A similar example was that one girl sang during the performance of the *“New journey to the west”*, clearly influenced by the librettos in the videos of traditional shadow puppet plays they watched.

Examples we showed here suggested that today’s children are not as unfamiliar with or uninterested in traditional culture as many may believe. The question for HCI researchers is then how to design technologies to resonate with their potential interest in traditional culture and provide easy access to it. We believe ShadowStory is one successful attempt towards this direction.

Between Digital and Physical Play

Many other digital storytelling systems [4, 19] successfully combined elements from the physical and the digital worlds. Although this was not an explicit design goal of ShadowStory, we also observed interesting examples how these two worlds interleaved with each other in children’s play:

Differing from many other storytelling systems, performance in ShadowStory was not based on direct manipulation but the orientations of handheld sensors, which could be controlled by wrist rotation only. Despite this, many children tried to create more direct mappings between the character’s position/action and those of themselves. For example, one girl waved her own hands when the character she controlled was doing so. One boy was controlling a character to fly in the sky, and while doing so he stood on a chair so that he was also physically above other performers. Such interesting correspondence seemed to add to the engagement with the story, and blurred the boundary between digital and physical play.

Children also tried to bring elements of their physical games into the digital stories they created. For example, the action of chasing as seen in their “One two three, freeze” game became a central part in the *“Catching rabbit”* story. Conversely, plots of their digital stories were often translated into physical role playing. Again taking *“Catching rabbit”* as an example, after its performance, three girls in the group started physically acting out the plots themselves in the roles they had taken. This role playing quickly evolved into a brand-new chasing game with set rules – the game was over whenever the “rabbit”

was caught, and played again with the roles reassigned. This “catching rabbit” game soon attracted many more players to join enthusiastically, including children who did or did not watch the original performance. Meanwhile, the girls who invented the game gained recognition and admiration in the class. Different from the “throwing the bean bag” game reported earlier, turn-taking in this game was handled seamlessly. Both the creativity and the collaboration promoted by ShadowStory were now translated back into the children’s real world play.

CONCLUSION AND FUTURE WORK

We presented ShadowStory, a digital storytelling system for children, inspired by and capturing key elements of the traditional art form of Chinese shadow puppetry. ShadowStory was designed to promote creativity and collaboration among children, and at the same time letting children become intimate with their cultural heritage. Findings from a field trial in classroom confirmed our approach was successful in achieving these goals, and revealed many interesting behaviors regarding children’s creative and collaborative play.

In the future we plan to more deeply investigate the longer-term effects of ShadowStory in promoting traditional arts and culture among children, as well as the transfer of creativity and collaboration skills from ShadowStory to the real life. We are also interested in designing other creative systems by drawing inspirations from other forms of traditional arts, and deploying them with children and/or adults.

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