

Supporting Communication between Grandparents and Grandchildren through Tangible Storytelling Systems

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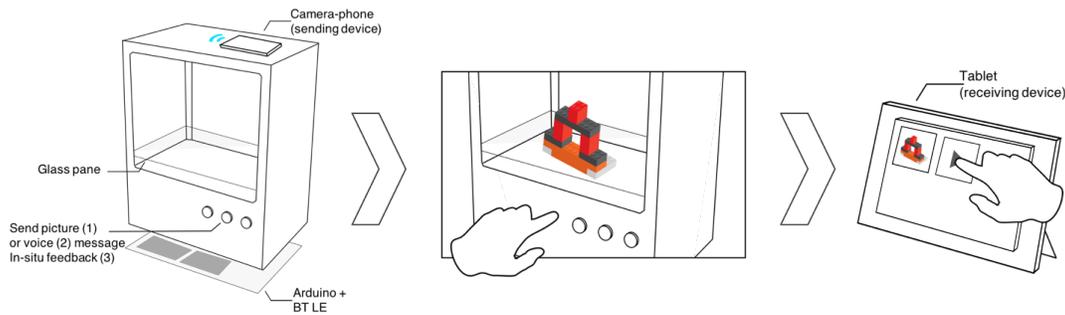


Figure 1: *StoryBox* is a tangible storytelling system that enables grandparents and grandchildren to share daily stories over a distance. They can easily stay in touch by placing objects in the box, writing on the glass pane, or recording voice messages.

ABSTRACT

Grandparents and grandchildren that live apart often rely on communication technologies, such as messengers, video conferencing, and phone calls for maintaining relationships. While some of these systems are challenging for grandparents, others are less engaging for children. To facilitate communication, we developed StoryBox, a tangible device that allows sharing photos, tangible artifacts, and audio recordings of everyday life. We conducted a preliminary study with two families to identify design issues, and further refine the prototype. Subsequently, we conducted a field study with four families for up to four weeks to better understand real-world use and examine inter-generational connectedness. We found that StoryBox was accessible, simple, and helped bridge the technological gap between grandparents and grandchildren. Children communicated asynchronously in a playful and idiosyncratic manner, and grandparents shared past family memories. We provide insights on how to ease communication between different generations, engage them in sharing activities, and strengthen family relationships.

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INTRODUCTION

The grandparent-grandchild relationship can offer an important source of mutual support that is unique from other family relationships. For grandparents, participation in their grandchildren's lives is often a source of joy and pride and helps create a sense of purpose and continuity [17]. For grandchildren, grandparents can be nurturers, historians, or positive mentors and role models [19]. Moreover, healthy relationships with grandparents has been associated with better mental health for children, especially those from single-parent families [31, 14].

However, geographical separation or social circumstances, such as divorce, makes it harder for grandparents and grandchildren to develop and maintain close relationships [37]. Although modern technologies, such as mobile phones, messengers, and video chat, mitigate this issue, they bring with them their own issues. For example, young children below the age of ten have difficulty maintaining phone conversations and older children typically require parental scaffolding [8]. Although video calls are more engaging, they are less familiar to grandparents [11], require installing programs or web cams, and pre-arranging a suitable time [1].

To address these multiple issues, researchers have created a variety of systems to facilitate and encourage communication between grandparents and grandchildren, including shared adventure games [22], reading over a distance [30, 28], and always-on family portals [16]. Some efforts have even focused on lightweight technologies for helping children keep in touch with their grandparents [20, 34]. However as researchers in this space have pointed out, “we do not yet have a solid grasp of how to bridge the conflicting needs and preferences” of intergenerational communication [22]. Older adults typically desire richer contact and want to know “nearly everything” about their grandchildren [11], and kids tend to have fluid and asynchronous communication patterns.

Our work aims to strike a balance between the communication needs and technological capabilities of grandchildren and grandparents. We developed *StoryBox* (Figure 1), a tangible storytelling system that enables different generations to share the daily stories of their lives. Storytelling in this context is similar to Kennedy’s category of “talking together about recent events in each other’s lives” [18]. With *StoryBox*, users can share crafted objects, pictures, written messages, and audio samples in an asynchronous manner.

From a children’s interaction design perspective, we developed *StoryBox* to integrate with youth play culture, particularly the practice of crafting, drawing, and sketching. As such, we envisioned our device as existing within a playroom or a common domestic area, enabling children to share any meaningful creations immediately with their grandparents. We focus on children aged 3 to 10 years old, since older children (particularly pre-teens) tend to generally talk less with their grandparents [8]. From an older adult perspective, *StoryBox* enables handwritten messages, sharing of old photos, and voice messages (akin to writing letters and talking on the phone). Our overarching goal was to create a device that was playful and favored free expression and creativity.

To better understand real-world usage, we conducted two studies with *StoryBox*. In the first study, we evaluated our system with two families for one week to investigate our design and gather initial impressions. Based on the feedback, we refined our prototype and conducted a longer field trial with four families for up to four weeks. We found that *StoryBox* integrated well into children’s crafting and play culture and required less parental scaffolding to use. For grandparents, the box provided a personalized view of their grandchildren’s lives and offered an opportunity to communicate back using methods they were more comfortable with (through handwritten notes or old family photos).

Our two main contributions are:

1. The design and implementation of a tangible storytelling system for supporting intergenerational communication and social connectedness.
2. A better understanding of grandparents and grandchildren’s practices and experiences with tangible storytelling systems.

RELATED WORK

Background of Family Communication

Grandparents and grandchildren often have difficulties in developing and maintaining close relationships over a distance. Supporting intergenerational communication is challenging because it requires a thorough understanding of grandparents and grandchildren’s communication practices and experiences. A variety of communication technologies to support family communication over distance have been previously presented in both HCI and industry. Commercial software applications, such as WhatsApp, Telegram or Skype, enable an exchange of text and multimedia messages, including pictures, speech, and video. Such communication applications are multipurpose and focus on users from all age groups. However, young children and older adults often struggle to use these systems, since their communication patterns do not reflect what is enabled by these applications. The design of *StoryBox* tries to integrate with the communication behavior of grandchildren and grandparents, by letting them easily share what matters in the moment. We see our work as a supplement to existing communication platforms, rather than a replacement.

Communication practices and experiences are age-dependent and, therefore, vary within a family. Tee et al. [34] researched communication needs and patterns of social interaction between families and showed that people often miss opportunities to communicate with their family members due to asymmetries in their daily schedules. Older adults, in particular, would like to increase the “quality” of communications to know what is going on in other’s lives. Ballagas et al. [2] further investigated intergenerational communication and found the phone to be the most important communication medium between grandchildren and grandparents. Grandchildren, however, often faced problems expressing their thoughts verbally over the phone. Evjemo et al. [8] also showed that communication over phone is not as rich and is insufficient for sharing information about everyday activities for both grandparents and grandchildren. To better understand this relationship, Olsson et al. [26] studied the needs for sharing life memories. They highlight the importance of face-to-face sharing and supporting that with physical mementos and storytelling. This study further reveals that children naturally focus on sharing their day-to-day practical experiences and grandparents tend to share the emotional and nostalgic component. Parents and grandparents try to maintain a constant presence with children, while children tend to engage discretely [39]. As a result, grandparents tend to limit their interaction with grandchildren to avoid annoying them or interfering too much in their lives [11].

Becker et al. [3] showed that grandparents and grandchildren have problems maintaining their relationships independently. Therefore, parents often are the “driving force” for fostering communication and building grandparent-grandchild relationships. When grandparents and grandchildren spend time together, they participate in various types of activities [18], such as storytelling [37]. In the context of this paper, we refer to storytelling as “*talking together about recent events in each other’s lives*” [18]. It is this idea of life sharing (e.g., physical

memories and day-to-day experiences) that we aim to support with StoryBox.

Systems for Life Sharing

There have been a variety of systems designed to facilitate communication between family members. For example, Judge et al. [16, 15] explored the use of an always-on video channel to keep families in touch. These systems enabled children to easily show an artifact to a connected family member and take part in other activities such as playing games and birthday celebrations.

Other systems have explored the exchanging of day-to-day photos as a way of connecting remote family members [4, 35, 24]. Many of these systems helped users to get better informed about activities of loved ones, take part in special events and experiences, and start conversations. Besides sharing experiences and activities, people also often utilize photo of items from their household to share moods or memories associated with these items [25, 23].

Our work aims to combine an easy-to-access share-point for children and older adults, that integrates in their day-to-day life without being obtrusive. We are repurposing the ideas of photo-sharing and voice messaging from previous works. With this, we aim to support children in sharing the results of their daily activities, e.g. play or craft, and encourage older adults to share memories and stories attached to everyday objects and old photographs.

Systems for Intergenerational Communication

Specific to children and adults, a variety of communication systems have been developed to support their specific needs. *Family Story Play* and *Story Places* support storytelling over a distance by providing either a video chat application and tangible interfaces or physical books to tell bed time stories [28, 10]. Druin [7] and Bonsignore [5] presented designs and evaluations of mobile storytelling applications. They found that integrated storytelling interfaces enable children to easily capture their personalized impressions about the world. *People in Books* presented by Follmer et al. [9] was another such application to support storytelling over a distance, where family member and children are included into the stories as characters. It provided a more immersive activity and was perceived as a catalyst for communication. In our work, we follow a more unstructured approach to communication, similar to open-ended unstructured play.

Another notable application called *Pop Goes the Cell Phone* uses a spring-loaded smartphone to automatically share self-portraits and video messages, and browse family photos [29]. However, children were sometimes not aware of their communication. For example, children's performances with the device were automatically captured by a front-facing camera on the phone, and shared with distant loved ones on Flickr. With StoryBox, our focus is on helping children explicitly share their own messages, without parental scaffolding. Other researchers, such as Moffatt et al. [22], have focused on identifying the challenging factors in a grandparent-grandchild relationship. They presented different design concepts to ease

social interactions between the two groups such as a collaborative reading application, shared photo-books, and shared game-play. StoryBox builds on these design concepts, but focuses on in-the-moment screenless sharing. Perhaps the work closest to our own is *ShareTable*, which uses a camera and projector to enable children and parents to videoconference and collaborate on a shared tabletop [40]. *ShareTable* was well received by parents and children and was preferred over regular videoconferencing. However, they found that synchronous video communication often lead to scheduling issues and creates a communication-focused environment, similar to a phone. StoryBox builds on asynchronous sharing, which makes it schedule-independent and tries to blend into daily activities, such as crafting, playing, scrapbooking, and knitting. Additionally, from a technical perspective, StoryBox was designed to be a more compact system in comparison to *ShareTable*, which allows it to be placed close to active areas, e.g., a children playroom or a kitchen counter.

With StoryBox, our focus was on alleviating the barriers of communication between different generations. For young grandchildren, this often means the sharing of crafts, drawings, stickers and short exclamations. For grandparents, the device provides a way to digitize analog memories, and use handwriting for communication. Both these use cases, can certainly be accomplished through traditional messaging platforms, such as Skype or WhatsApp, but as other researchers have pointed out, some grandparents feel trepidation in using these applications [32]. Moreover, we strongly believe, these applications are not supportive of children's crafting culture.

STORYBOX

Initial Design

We based the design of StoryBox (Figure 2) on previous work by Wallbaum et al. [38], which was supported by semi-structured interviews and focus groups. Initially, StoryBox was designed as a tangible system for sharing memories, experiences, and feelings. It aided the process of creating visual stories and sharing them with connected family members and friends. These stories consisted of multiple pictures, combined to create an animation, allowing users to alter each frame and tell a story.

Before delving into the details, we provide a simple scenario of how a child might use the system to share an artifact with her grandmother. The child begins by crafting a clay bear and places the bear on the StoryBox glass pane. She takes multiple images of the bear using the camera button while moving the bear slightly each time. StoryBox automatically creates an animation and replays it for review. She sends the animation to her grandmother by pressing the send button. The paired StoryBox on the grandmother's side, automatically replays the received animation.

StoryBox utilizes an Arduino Uno, RGB LEDs and five buttons on the front side of the box. The upper three buttons send to the three most frequently used contacts and the lower two buttons are used to take and delete a picture, respectively. The hardware is enclosed into a wooden box with a glass surface for writing and drawing. The box is big enough to place

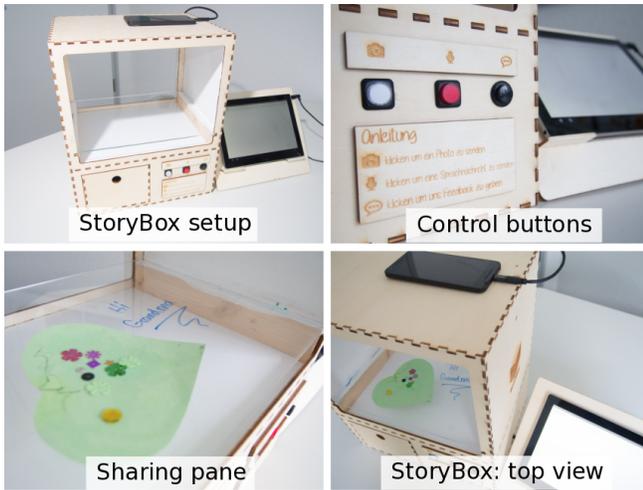


Figure 2: StoryBox design.

objects of different sizes inside (L = 30cm, W = 25cm, H = 20cm). Additionally, the StoryBox contains a smartphone on top of the box and a tablet underneath the glass pane. The smartphone is used for taking pictures of the glass surface inside the box and is activated by a button. It saves and shares the content, which can be reviewed by users in a chat-style view. The tablet is used to enrich the image drawn on the glass pane by adding depth to the drawing or to emphasize the foreground objects. The StoryBox also has a small drawer to store supporting materials, such as sponges and markers. All of the content shared between the boxes are encrypted and saved on servers with limited access.

Exploratory Study

To identify early usage patterns, sharing behavior and understand user experience, we investigated the initial design of StoryBox in an exploratory study with two groups of families for a period of one week.

Participants and Apparatus

We recruited two groups of families: the first consisted of two grandchildren (8f, 11m) and their grandparents (67f, 68m). The second group consisted of two grandparents (64f, 65m), their daughter (30f) and her child (1f). Each family was provided with two interconnected StoryBoxes: one at the grandparents' house and another at the children's residences. We also provided different colored markers, plastic emoji tokens and print-outs of pictures used in the Photographic Affect Meter [27] to augment messages with emotional expressions.

Procedure

Before the evaluation, we conducted a semi-structured interview regarding the participants' experiences with modern communication technologies. Afterwards, we installed a StoryBox and instructed the participants about its functionality. The families were free to use StoryBox according to their schedules and preferences. They were free to choose the location of the system in their household. At the end of the study, we conducted another semi-structured interview regarding the

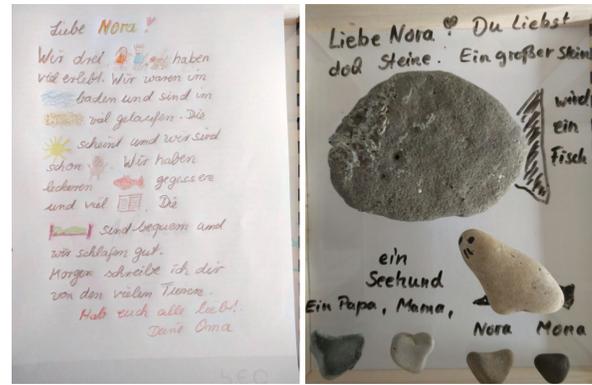


Figure 3: Example messages from the exploratory study showing a) a written letter and b) a crafted composition of decorated stones with associated descriptions

shared content, influence on the connectedness among the family members, and their experience with the system.

Results

Overall, StoryBox was perceived positively by both, younger and older participants. They considered the system to be pragmatic while being attractive and engaging to use. Participants found StoryBox engaging and shared messages throughout the whole study period. They reported feeling motivated to exchange messages with their connected partners. Six participants observed an increase in communication with their connected partner and five of them shared creative content they had not done before. P1 remarked, "We started collecting things from the nature to share it with our grandparents. This is more interesting compared to the usually shared messages". Two participants mentioned that the style of communication with StoryBox was "more intense and focused than normally".

After the interviews and analyzing the shared content, we found a strong need for the expression of verbal messages, especially for grandparents. They also mentioned that phone and messaging are the most common communication channels used within their families. In our brief study, grandparents were sending pictures of hand-written letters to their grandchildren. Tangible objects shared among families were also often augmented with written explanations (Figure 3). Animation was used infrequently with participants citing it as too complicated to use with less added value. They also mentioned the need for an easier way to review received messages. Some participants suggested the use of an external device like a digital picture frame. Lastly, we found that switching to the review screen was especially complicated to do for the children.

Final Design

Based on the results from the exploratory study, we modified StoryBox in the following ways: (1) inclusion of audio messages, because we found a strong need for verbal communication and (2) exclusion of animations, which were rarely used in the exploratory study. Therefore, we changed the functionality of the buttons to send: (1) pictures, (2) audio messages to family members, and (3) feedback to experimenters. Since the

animation feature was rarely used, we repurposed the delete button to enable participants to send in-situ feedback to experimenters. We also added a simple wooden stand for interacting with the tablet in an upright position.

FIELD STUDY

Since our system was designed to be used in a household environment, we conducted a field evaluation to better observe real world use, similar to previous works in this area [40, 36]. Additionally, our methodology drew on several approaches including technology probes [12] and research through design [41]. We also periodically interviewed participants and logged system usage and content based on the methods from MILCs [33].

Participants and Procedure

We recruited four groups of families with grandparents aged from 63 to 76 and grandchildren aged from six to ten years. All the families live in different towns/cities from 5 to 300 kilometers away from each other. A brief summary of all family groups is shown on Table 1. In the following paragraphs, we provide a short descriptions of the families in our study.¹

Family 1. Martin is the 10-year-old son of Lisa and John. Martin and his grandparents, Richard (66) and Marta (66), describe their current communication as fairly frequent. Marta described her relationship with Martin as strong, because both of them use WhatsApp messenger regularly. Richard, Martin’s grandfather, calls his grandson every other week and has trumpet lessons with him every month. Since Marta positions herself as a confident and regular user of WhatsApp messenger to communicate with Martin and Lisa, Richard sometimes asks Marta to send his grandson and daughter a greeting on his behalf. Martin spends 2-3 nights per month with his grandparents, up to one week per month with his father John and the rest with his mom. In Martin’s home, the StoryBox was set up in his bedroom on the desk; in Richard and Marta’s home, it was in the guest room.

Family 2. Lila (6 years), Anna (8 years) and Thomas (10 years) are children of Michelle and Michael. Their grandparents - Manuela (74) and Wilhelm (74) - live 20-30 minutes away. Grandchildren and grandparents describe their communication as relatively frequent and meet each other almost every weekend for dinner. To stay in touch with their grandchildren, Manuela and Wilhelm prefer phone communication. Even though Manuela and Wilhelm have WhatsApp messenger installed on their smartphones, they have difficulties sending messages to their grandchildren, so they prefer to use it as a receiving device. StoryBox was set up in Thomas’ room based on the general agreement of the family. Since Wilhelm described his relationship with the grandchildren as strong, he preferred StoryBox to be set-up in his office, where he spends most of his time.

Family 3. Six year old Tiffany lives with her parents Emilie and Peter in the same city as her grandparents Frank and Angelika. She has two younger sisters who were too young to participate in our study. She joined first grade just as the

study started. Tiffany and her sisters visit their grandparents about once a week. Frank and Angelika mentioned that they would like to know more of their granddaughters day-to-day life. The parents and grandparents of Tiffany are share pictures via WhatsApp. When Tiffany is allowed to use her mothers phone, she sends emojis that she thinks look cute. Frank and Angelika collect printed images of their grandchildren and compose them into photo-books. Angelika maintains a diary of her granddaughters important life events.

Family 4. Rickarda (6) and Anthony (8) live with their parents Lara and Sebastian in a small city. Their grandparents Lisa and Ernst live about 300km apart from their grandchildren. Due to the long distance, they rarely see each other. Usually, Lisa and Ernst call their grandchildren using the phone. They mentioned that the kids are not very attentive using the phone and do not share many things when talking. When introduced to StoryBox, Ernst was rather skeptical and Lisa was the driving force for communication. The parents of Rickarda and Anthony share pictures using WhatsApp with their grandparents. Although, they like receiving these messages, both grandparents are not technical savvy.

	Grandchild age	Grandparents’ age	Distance
Family 1	ten (M)	66 (F) and 66 (M)	6 km
Family 2	six (F), eight (F), ten (M)	74 (F) and 74 (M)	20 km
Family 3	six (F)	63 (F) and 67 (M)	5 km
Family 4	six (F), eight (M)	76 (F) and 76 (M)	300 km

Table 1: Summary of participants’ data. F = female, M = male.

The evaluation varied anywhere from two to four weeks and consisted of three semi-structured interviews per family. Since the field study was conducted over a three month period, it overlapped with vacation and school holidays. As a result, two families were able to participate for only two weeks. Before the evaluation we interviewed the participants regarding their existing familial relationships, their experiences with communication technology and communication patterns. We used a 7-point Likert scale to estimate current communication technology use. Afterwards, we setup the StoryBoxes and instructed participants about its functionality. The families were free to use StoryBox according to their schedules and preferences. Participants were also free to choose where to place the system in their household (Figure 4). For privacy reasons, all shared data was encrypted and could only be accessed by experimenters. We also supplied the families with additional markers and cleaning materials to ease the usage of the system.

From the pre-questionnaire we found that most of participants (86%) met each other in person almost every month. The most common communication channels between grandparents and grandchildren were the phone, WhatsApp messenger and face-to-face meetings. Grandparents and grandchildren mostly talked about recent events or household routines, such as problems with friends at school, future get-togethers and birthday greetings. When they use WhatsApp, they shared pictures and videos from their day-to-day activities. All of participants perceived new communication technologies as enjoyable (M

¹All names anonymized.



Figure 4: Examples of StoryBox's setups in different households.

= 6, IQR = 1.5), but were only moderately interested in new technologies ($M = 4$, $IQR = 2.25$). The participants also considered themselves as average users of these technologies ($M = 4$, $IQR = 2$).

We conducted interviews with the families in the middle of the study and at the end. We asked participants questions regarding the content they shared and its purpose, the influence of StoryBox on the connectedness among the family members and their overall experience with the system.

Analysis

We analyzed the data using Biemans et al.'s established coding categories [4], which were used to study social connectedness between friends and family. The categories include: (1) messages, (2) greetings, (3) everyday life, (4) regular events, (5) special events, and (6) something funny or aesthetic. *Messages* refer to content that shows a person something new, *greetings* contain greeting messages, *everyday life* refers to content about normal things in and around the house and environment, *regular events* contain routine-based content, *special events* refer to special moment, such as holidays and birthdays, and *something funny or aesthetic* refers to funny or cheerful content.

These categorizations were used to analyze the threads of messages shared among family members. By "thread" we refer to a sequence of connected messages under the same topic. Audio messages were transcribed and printed together with shared photos. An initial coding was conducted by two members of the research group. To visualize categorization, we used affinity diagrams. Each thread was classified separately and the final category was discussed until both researchers reached an agreement. Furthermore, we compared the affinity diagrams with the qualitative data from all three interviews. This process was used to distill a set of distinct themes.

FINDINGS

Quantitative Results

The amount of messages shared over the period of the study varied among families, however, the average number of messages per thread was similar (about 2-3 messages/thread). Among all families, children were sharing almost two (Family 1, 2, 3) or even three times (Family 4) more content than their grandparents.

During the study, grandparents of Family 1 called their grandson once and visited him three times. Grandparents of Family 2 visited their grandchildren twice during the study and called them once. The child of Family 3 visited their grandparents six times. Children of Family 4 were rarely using other communication channels before the study, but they started calling their grandparents more often during the study to discuss the shared content and StoryBox itself.

Pictures were the predominant type of shared content for Family 1 (88%) and 3 (64%). Whereas for Families 2 and 4 pictures and audio messages were equally used (Table 2).

	Family 1		Family 2		Family 3		Family 4	
	15 days		15 days		23 days		31 days	
Duration	15 days		15 days		23 days		31 days	
Threads	23		50		52		77	
Messages	58		167		97		152	
Pictures	51		82		62		80	
Audio	7		85		35		72	
	GC	GP	GC	GP	GC	GP	GC	GP
Sent	34	24	109	58	59	38	116	36
Received	24	34	58	109	38	59	36	116

Table 2: Number and types of threads/messages shared between families. GC = grandchildren, GP = grandparents.

Overall we observed a novelty effect during the first three days of the study. A few usage peaks were observed when grandparents came back and shared vacation pictures (Family 4) and when birthdays occurred (Family 2 and 3) (Figure 5).

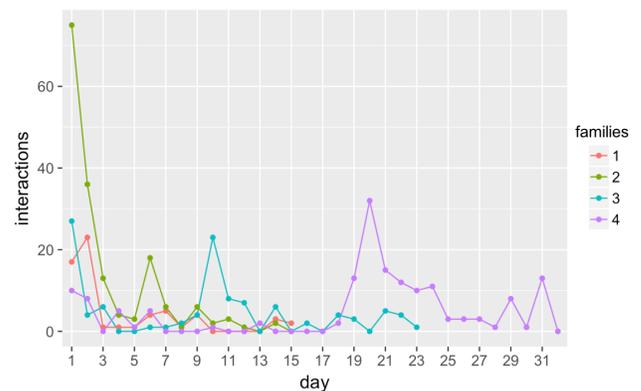


Figure 5: Usage of StoryBox throughout the study period for all families.

The Likert scale results regarding the influence of StoryBox on the communication between grandparents and grandchildren

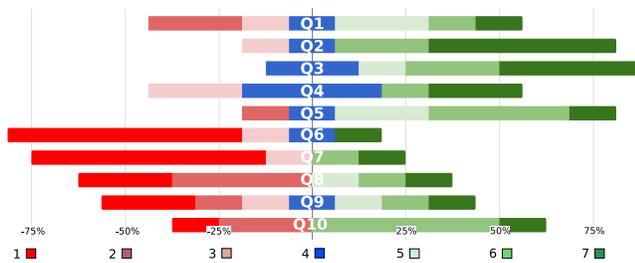


Figure 6: Likert scale results regarding communication among grandparents and grandchildren using the StoryBox (1 - strongly disagree, 7 - strongly agree).

showed that it helped to tell how their communication partner felt that day (Q1), see how much they care (Q2), make them feel closer (Q3), make them think about the shared content (Q4) and make them feel better (Q5). Moreover, grandparents and grandchildren did not feel obligated to communicate (Q6) or feel isolated (Q7), did not reveal much of their memories (Q8), were sometimes sad if waited for too long (Q9) and were often surprised to receive unexpected content (Q10) (Figure 6). Some participants were not receiving the responses to their messages immediately, which often made them think that the children were either busy or the system was not working properly. This often led to simple reminder and acknowledgement requests from the grandparents.

During the categorization process we derived three additional categories for information sharing, because our work also included the sharing of tangible artifacts (in comparison to Biemans et al. [4] picture only sharing work). These three categories are: (1) *artifact* refers to explanations on how to use communication technology, (2) *communication reminder* contains reminder and acknowledgement requests and (3) *feedback* consists of messages to experimenters from users.

Families shared different types of messages throughout the study, which we grouped into threads and categorized into eight types of content (see Analysis). The most frequent type of content category among all families is *funny/aesthetics* (83 threads) and included pictures of handmade objects, musical recordings, pictures of faces, hands and heads and content related to remote games. The second group of shared messages were related to the categories of *everyday life* (30 threads), *messages* (27 threads), *artifact* (22 threads) and *greetings* (19 threads). *Everyday life* included different kinds of day-to-day activities (cooking, writing, drawing, accidents, homework, food), *messages* contained pictures of books or articles recommended by grandparents for their grandchildren to read or pictures and audio of poems, *greetings* mostly included "hi" messages and "kisses" and *artifact* included discussions about the functionality of StoryBox or explanations of children for grandparents, what objects to use for drawing/removing the content from the StoryBox. The fewest messages belong to the categories *special events* (10 threads) and *reminder to communicate* (8 threads). *Special event* included messages regarding birthday wishes, horse riding, vacation impressions or invitations to do something together and *reminder to com-*

unicate contained messages such as "Please let us hear from you when you are back home" or "Please let me know whether you received my drawing". The summary of content shared between all four groups of families is shown in Table 3.

Qualitative Results

Tangible Communication: From Drawing to Crafting

StoryBox was designed to support children's crafting behaviors and the exchange of tangible memories from grandparents. Even though Wilhelm and Thomas (Family 2) were using WhatsApp messenger regularly before, they would not normally share old pictures due to the technical difficulties. "I wouldn't share old pictures usually. The box was the inspiration to share it with my grandchildren. They knew about this one puppet that their mother loved as a child. And now I could share a picture showing them together" (Figure 7) (Wilhelm, F2). Tiffany (grandchild, Family 3) shared a picture of a flower with her grandparents, which she and her friend included into their play of "marriage". This flower initiated a conversation between them, where they explain what and how they played. This would normally not have happened among them, since Tiffany has no smartphone and uses her mom's smartphone to share emojis. The StoryBox was often perceived by children as a toy. They were using it as an alternative for a game after getting bored with playing other games.

Grandchildren got themselves quickly engaged into crafting messages for their grandparents and perceived the StoryBox as a creativity platform. They also started drawing pictures, making something out of clay or searched for other objects that played an important role in their lives. "Sending pictures was a little bit more fun, because you can get much more creative" (Anna, F2). Additionally, her parents commented: "She likes to search for things in her room, which she can share with her grandparents. She liked that the most". Some grandchildren also invited their parents to create something together and share it afterwards with their grandparents.

Grandparents liked the fact that their grandchildren used hand-writing for communication instead of typing text using software-based applications. "I was happy, that my grandson had to write with a pen, because they do not do that very often nowadays. [...] using WhatsApp, they just sent voice messages and they don't learn how to write" (Marta, F1). Another grandmother (Angelika, F3) used the StoryBox to teach their granddaughter to write: "I have sent examples of how to write number 3, because my granddaughter had to learn it for school".

Inter-generational Communication and Connectedness

We found that some children were thinking about what to say before recording the message, which helped them to better express their thoughts than over phone. "We were surprised that he communicated so much verbally and told stories in quite some detail. We think, when using the phone he is surprised and does not know what to say. With the box, he could think about what to say before and then record" (Wilhelm, F2). The same family mentioned that the communication via StoryBox increased social connectedness between them and their grandson Thomas, even though they meet each other almost every week for dinner. "It has increased the feeling of being

Artifact (22)	Everyday Life (30)	Special Event (10)	Funny/Aesthetics (83)
<ul style="list-style-type: none"> • Explanation of usage to a partner • Usage of different materials for cleaning the glass • Test messages to try functionality • Requests to send confirmations 	<ul style="list-style-type: none"> • Experience sharing • Questions about location and activity • Accident sharing • Appointment request • Goodnight wishes • Reminder to communicate • Food • Weather • Homework and stories from school 	<ul style="list-style-type: none"> • Birthday discussion • Visiting friends, vacation • Invitation to do something together • Horse riding 	<ul style="list-style-type: none"> • Playing a remote game • Singing songs • Handmade objects • Playing a song on a trumpet • Hands, heads and faces of kids • Pictures, books, flowers, toys
Message (27)	Greetings (19)	Reminder to Communicate (8)	Feedback (3)
<ul style="list-style-type: none"> • Pictures of articles/books to read • Audio and picture of a poem 	<ul style="list-style-type: none"> • Messages with names • Greetings to parents over kids • Greeting words and kisses 	<ul style="list-style-type: none"> • Messages to remind about communication 	<ul style="list-style-type: none"> • Suggestions to share crafted emojis

Table 3: Types of content and number of threads (in brackets) shared among families.



Figure 7: Examples of messages exchanged between grandparents and grandchildren. From left to right: knitting results, crafted items, picture of grandchild with newborn child, hand greeting, homework from school, drawings of toys.

connected intensively! Even the physical closeness, when we were visiting, it was much stronger than before". Moreover, grandchildren started communicating with their grandparents themselves, without their parents asking them to do so. "I have decided to send something and then also did it by myself." (Thomas, F2). "My parents did not help us at all. I have used the box exclusively." (Tiffany, F3).

Grandparents were often inspired by the messages sent by their grandchildren and therefore were motivated to use StoryBox. One grandmother (Manuela, F2) mentioned: "... my husband showed me a message sent by our six years old granddaughter. It made me so happy that I wanted to answer her. That is why I also started sending her messages". As mentioned previously she usually uses WhatsApp messenger to receive messages, but not to send them. In addition to the StoryBox, some children started using other communication channels, such as telephone, more often than before. "My children wanted to talk to their grandparents about content, that they shared beforehand using the box. So they started to use the phone by themselves" (Lara and Sebastian, F4).

Almost half the participants used StoryBox exclusively for communication during the study. "I only have used other communications means with my friends and other family members, but not with my grandparents anymore. We just used this box" (Martin, F1). Other families used StoryBox as a supplement to other communication channels. "[...] when there was something important, then we would use other things to get an answer directly. When using the box, we exchanged more fun messages" (Wilhelm, F2). Exchanging messages

through StoryBox on a regular basis made both grandparents and grandchildren think about each other more often and be more aware about each others lives. "After sometime of box usage I realize that my grandchildren really fulfill my life" (Frank, F3). One of grandchildren was regularly telling her mother stories shared by the grandparents. Her mother Emilie remarked, "She liked it, when her grandparents told her what they did and asked questions about her day. Afterwards, she always came to me and told me the news."

Artifact Design

From the three interviews we found that both grandchildren and grandparents quickly understood the concept and functionality of StoryBox. For example, grandparents mentioned that it was easy for them to share pictures and voice messages using the system. Richard and Marta from Family 1 used messenger applications to receive pictures from their daughter, but had problems responding to them, because they considered themselves "very bad with technology". Martha remarked, "We use WhatsApp, to receive messages from our daughter. Sometimes even pictures showing our grandchildren. But we don't know how to send pictures or voice messages back. So we can not react to these messages."

Most grandparents felt positive about the design of StoryBox. "It looks like a self-made TV. It kind of looks like the one we had when we were younger" (Wilhelm, F2). One of the children also mentioned that she would prefer a more colorful and playful design, for example, "with some colored pictures or patterns printed on it" (Anna, F2). Both grandparents and grandchildren described StoryBox as a tangible reminder that

fosters communication with each other. *"It reminded us to send something, when we saw the box in our living room"* (Frank, F3). At the same time most participants would have preferred to have some notification on received messages. *"It would be better if the box would inform us, when a new message has arrived. Now we have to check every now and then"* (Manuela, F2).

Grandchildren had no problems sending messages, but sometimes got stuck when receiving them using the tablet. As one mother explained: *"Using the Box was very easy for her, but with the tablet she sometimes pressed a wrong button and did not know how to move on"* (Tiffany, F3). Grandparents also faced a few issues; one of the participants unintentionally uninstalled the StoryBox application. Some grandparents mentioned that they would like to see previously shared content. Angelika (F3) remarked: *".. we sometimes don't know what has been sent to our grandchildren"*. In addition, we found that many participants missed the timely information of messages and started mentioning the time and date within voice messages after some time. *"Knowing the time and date when we have received a message is very helpful. My grandson has started to do so and I found it was a great idea"* (Wilhelm, F2).

DISCUSSION

There is a fundamental difference in the communication styles of grandparents and grandchildren. Young children typically have limited attention spans and communicate in an intermittent and asynchronous manner. Older adults on the other hand, are willing to invest time and effort in composing messages and prefer having longer synchronous interactions. Moreover, the relationship between the two groups tends to be asymmetrical with grandparents often giving more than they receive [21]. While StoryBox may not be fully accommodating of both communication styles, there is some modest evidence that suggests it offers a *personalized sense of intimacy* for grandparents and a *playful and creative* communication platform for children. In the subsections below, we take a "step back" and explore the reasons why and reflect on the implications of this work.

Designing for Engagement and Creativity

A common message sent by children in our study was a picture of their hands, reminiscent of hand stencils from prehistoric cave art that sought to make a connection with the world [6]. This highlights the need to help children express themselves naturally and creatively. The lightweight and flexible nature of StoryBox helped kids to appropriate and digitize daily artifacts from their lives such as drawings, clay figurines, books, flowers, and toys. This supports the naturally playful and often creative input of the child. The children's artifacts are not exemplars of ideal communication, nor are they intended to be. Instead, they are intended to tap into an impulse for creative atypical conversation that supports a high level of individual decision making. A potential benefit of enabling free expression in this context is that it requires less parental scaffolding, a problem that researchers have cited in the past as being needed for grandparent-grandchild relationships [2, 11, 30].

We believe one of the factors that aided engagement and creativity, was simply the tangible nature of StoryBox. As a sizable physical object (relative to a mobile phone) occupying some desk space, it was hard to ignore and reminded participants in our study to initiate communication. While we did not find evidence of children crafting more because of StoryBox, it did offer a lower-barrier for communication through their (already existing) daily crafting practices. For older adults, StoryBox provided a simpler, larger interface (akin to an old television as mentioned by Wilhelm, F2) with the singular purpose of communicating with their grandchildren. As a result, grandparents were more inclined to regularly monitor and share messages via the device. For some groups, it even replaced the usual or traditional forms of communication.

Multigenerational Design

As alluded to earlier, there are inherent complexities in designing accessible communication technologies for different generations. Admittedly, StoryBox is geared more towards children's crafting and play culture, even though it is easier to use for grandparents (from a technological perspective). Grandparents in this case, accommodated and tailored the content of their communications to suit their grandchildren. As other researchers have pointed out this fundamental imbalance underpins research in this area [20, 22].

However, the asymmetrical nature of familial relationships and its consequent effects on technology design need not be seen as a limitation, if we consider what is important to both user groups. For grandparents, having a personal sense of intimacy with their grandkids is essential, while for children being able to express themselves on their terms is most important. Throughout our analysis, we found many messages from children sharing silly, playful, idiosyncratic voice messages, artifacts, and creations. These range from children telling their grandparents a story with an overly excited voice (that is sometimes difficult to understand), to pictures of crafted objects (that are difficult to identify). This type of informal communication is different from how children are typically asked to communicate with their grandparents through phone or video chat. Perhaps the idea that StoryBox tries to embody is this notion of "making as a form of communication." This idea has been explored in the past in cross-cultural settings to overcome significant differences in language and culture [13]. We feel these differences are sometimes also true of grandparents and grandchildren.

For grandparents, StoryBox offers a view into their grandchild's world and creates potential opportunities for intimacy and personal connectedness. In the case of Wilhelm and Manuela (F2), this view came as a surprise; they never knew their grandson was so articulate, considering that he was often quiet during phone calls. For others (Richard and Marta, F1), StoryBox was a way to relay family history through old photos, allowing the older adult to serve as family historian. This idea of a curator of family stories, culture, and heritage is discussed by Korhaber and Woodward as one of the five central roles played by grandparents [19]. Perhaps, more importantly, StoryBox can offer older adults a sense of intimacy with their grandkids. This intimacy might be expressed through the tone

of a voice message, or the unique handwriting of their grandchild. Although these are very simple touches, they allow for a level of expression that is often lost in texting and email.

While older adults would be better served by technologies that allow for a more focused, intense means of communication [11], this is often not possible with younger children. The key, as Lindley comments, “lies in making both sides aware of differing expectations and helping them to overcome these” [20]. She further highlights the use of a lightweight message to trigger a richer more satisfying conversation. For some groups this was indeed the case with StoryBox. The children from Family 4 for example, started using the telephone to discuss content they had shared. Similarly, Wilhelm and Manuela (F2) mentioned the increased feeling of physical closeness and connectedness when visiting their grandkids. In this sense, StoryBox was helpful in meeting the communication needs of both groups more fully.

Bridging the Non-Digital and Digital

At the forefront of inter-generational communication are the different technological backgrounds of the older adults and children. Children today are raised in the atmosphere of mobile phones, tablets, and smart TVs. Grandparents, however, are typically from a time of land-line phones, hand written letters, and cathode ray TVs. In a sense, these two groups are from different technological “silos” where the cognitive requirements of technology widely vary. The mobile phones of today are hardly just phones compared to the fixed land-lines of yesteryear. These new developments are often overwhelming and confusing to older adults. Even in our modest study, we found grandparents who experienced frustration in sending pictures and voice messages via WhatsApp.

In this landscape, the aim of StoryBox, was to serve as a technological bridge or scaffold between two vastly different generations. From the perspective of grandparents, StoryBox was helpful as a singular communication channel with their grandchildren, much like technologies from their time. Moreover, it provided an interface for sharing non-digital content such as old printed photos (Marta, F1). This is particularly important considering that for many grandparents, memories are not purely “virtual” or cognitive, they often have accompanying physical artifacts that enrich their own sense of narrative history.

Another aspect of the tangible interaction interface that helped bridge the technological gap for grandparents was the glass writing surface. Handwritten messages are closer to their technological “silo” and a burgeoning (and perhaps short-lived) part of the children’s. Many of the grandchildren in our study were just learning to write, an activity grandparents were already experts at. We observed older adults helping their grandkids with writing letters and numbers using the StoryBox. We also recognized how it was a source of pride and joy to see themselves as a part of their grandchildren’s lives. Perhaps one of the strengths of StoryBox was that it facilitated a level technological “playing field” for both user groups.

LIMITATIONS

StoryBox is not without its limitations; during our studies, we found many participants reporting that the StoryBox should notify them about new incoming messages from the connected partner. We designed StoryBox to be an asynchronous communication platform, but we discovered that participants had additional needs. Grandparents and grandchildren requested time-related information particularly, when messages arrived. This was important because messages were sometimes read on a different day than they were received.

A key limitation of our research is, that StoryBox is designed for younger children below the age of ten. With this age group children, crafting and technology use is more prevalent than in comparison to teenagers. It is unclear, how StoryBox will function with older children especially with respect to usage patterns as well as acceptance of the system in general. It may be considered too “childish.” Lastly, our results are based on an evaluation of up to four weeks where we noticed a small decay in system use. It is unclear how the usage of the system will fare for longer time periods.

CONCLUSION

In this paper, we present the design and implementation of a tangible storytelling system – StoryBox – for sharing photos, tangible artifacts, and audio recordings of everyday life. To better understand grandparents and grandchildren’s real-world use and examine connectedness, we evaluated StoryBox in a preliminary study with two families and a subsequent study with four families for up to four weeks. We found that StoryBox enabled children to express themselves freely in a playful manner, was simple to use, and helped bridge the inter-generational technological gap. We further provided insights on how to ease communication between different generations, engage them in sharing activities, and strengthen family relationships.

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