2021 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct) | 978-1-6654-1298-8/21/$31.00 ©2021 IEEE | DOI: 10.1109/ISMAR-Adjunct54149.2021.00063

A Mixed-Reality System to Promote Child Engagement in Remote Intergenerational Storytelling

Jennifer Healey*
Adobe Research

Duotun Wang†
University of Maryland
College Park

Curtis Wigington‡
Adobe Research

Tong Sun§
Adobe Research

Huaishu Peng¶
University of Maryland
College Park

Abstract

We present a mixed reality (MR) storytelling system designed specifically for multi-generational collaboration with child engagement as a key focus. Our "Let's Make a Story" system comprises a two-sided experience that brings together a remote adult and child to tell a story collaboratively. The child has a mixed reality phone-based application with an augmented manipulative that controls the story's main character. The remote adult participates through a web-based interface. The adult reads the story to the child and helps the child play the story game by providing them with items they need to clear the scenes.

In this paper, we detail the implementation of our system and the results of a user study. Eight remote adult-child pairs experienced both the MR and a traditional paper-based storytelling system. To measure engagement, we used questionnaire analysis, engagement time with the story activity, and the word count of the child's description of how the story should end. We found that children uniformly preferred the MR system, spent more time engaged with the MR system, and used more words to describe how the story should end incorporating details from the game.

Index Terms: Human-centered computing—Augmented Reality—Story Telling; Human-centered Interface—Human Factors—Family Communications

1 Introduction

Exploring and sharing stories has been a long-lasting way of maintaining and enhancing intimacy among family members. However, sharing stories can be challenging when family members, such as grandparents and their children, are separated by distance due to relocation or unexpected incidents such as global pandemics.

In recent years, the popularization of video conferencing applications such as Zoom, Skype, or Facetime makes it possible for family members to interact over distance for a sense of togetherness. Video chat has been demonstrated in previous research to be more preferred than audio-only communication for children due to its ability to communicate using a combination of visuals and sounds [3, 14]. However, traditional video conferencing tools are not explicitly designed to promote or facilitate interactions with children, as engaging children's attention over long periods is often challenging. [21]. Video conferencing also lacks interaction features that play a key role in events such as storytelling [16, 20] and collaborative edition.

In this paper, we present "Let's Make a Story", a mobile story-sharing system in a remote setting using mixed reality (MR). We hypothesize that an MR system where the adult and child can see each other as in a video conferencing tool and interact with the same piece of digital content embedding in the physical environment can promote high child engagement.

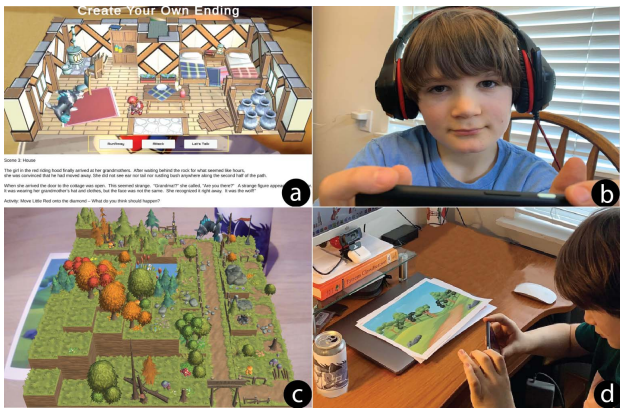

Figure 1: The "Let's Make a Story" system makes it possible for the adult and the child in a remote setting to experience the same story simultaneously. a): The adult can read the story script while watching the child's gameplay from a web-based client. b) and c): The child can generate the virtual story scenes with the mobile MR system while hearing the story from the adult. d): The child can manipulate a can-controlled protagonist to interact with virtual story-related events controlled by the adult end. The child featured in the paper is the child of one of the authors.

System-wise, "Let's Make a Story" builds on the paradigm of a two-sided experience that aims to address the needs of both the adult and the child. For the adult, we developed a web-based application that contains the words of the story, the live streaming of the virtual story environment from the child, and various controls of it (Fig. 1a). The adult controls the pace of the story and actions that are necessary for the story to advance. While reading the story, the adult can also see the child and her reaction from a webcam in real-time. For the child end, we hope to make story sharing playful by resembling phone video game experiences that are familiar to today's children. Thus, "Let's Make a Story" runs on a mobile phone environment and builds upon mixed reality features. Specifically, the mobile application allows the child to generate the virtual story environment from paper printed story scenes, and control the protagonist of the story using a physical can wrapped in an MR triggering image (Fig. 1d). As the story progresses, the child can make the can-binding protagonist interact with virtual events launched by the parent from the web application. The twin experiences allow both parties to share the same virtual story content, see each other in real-time, and having the storytelling activity in an interactive manner (also seen in Fig. 3).

To evaluate our system, we conducted a study with eight adult-child dyads comparing to a traditional paper-based storytelling activity via video chatting. We employed a within-subject study design, where all dyads experienced both conditions with the experimenter

*e-mail: jehealey@adobe.com
†e-mail: duotun@umd.edu
‡e-mail: wigingto@adobe.com
§e-mail: tsun@adobe.com
¶e-mail: huaishu@cs.umd.edu

978-1-6654-1298-8/21/$31.00 ©2021 IEEE
DOI 10.1109/ISMAR-Adjunct54149.2021.00063

acting as the remote adult. We analyzed post-study surveys, measured story time and the word count of the child's dialogues in story generation to evaluate engagement. Our study showed that the children uniformly preferred the MR system. The adult-child pairs spend more time and use more words to describe and recreate the story ends.

In summary, we contribute a working mixed reality storytelling system to facilitate parent-child engagement over distance. Our study revealed that our system is preferred over a similar, paper-based reading activity using video conferencing.

2 Related Work

People have a strong desire to stay connected with their remote family members [18, 22, 25]. This remains true especially for children when they and their caring adults are separated. In cases like this, video conferencing has been shown to be a convenient tool for remote family connections [16]. Comparing to the traditional voice chatting, video conferencing is more engaging, as children are often at a loss when it comes to sustaining conversation without expressing themselves physically [2, 3, 14]. Video chat also allows children to assert their own participation more easily by putting something (an object, their body) in front of the camera rather than needing to find words to share [9]. For elderly family members such as grandparents, video conferencing was "the primary, if not sole, motivation" to chat with their grandchildren [2].

While being one of the primary channels to connect remote family members, commercial video conferencing tools are not designed with children in mind. Lacking the shared visual space, referencing, [10, 11] and interactive features makes retaining children's attention challenging [21]. To promote intergenerational communication, researchers have looked into new systems built around the concept of remote storytelling. For example, Sharetable [28] allows remote story sharing using a custom system built around large-scale tabletop; Family Story Play system [20] uses a paper book with an augmented frame that plays videos of a popular television character at different parts of the story; StoryVisit [21] uses a shared ebook that allows video chat to be augmented with remote storytelling. All these studies indicate that remote storytelling increases child engagement to some extent. However, as all these systems are built upon the notion of remote video conferencing, shared stories are essentially digital assets on a screen, not embedded within the user's reality. This is still far from a real in-person storytelling experience, where both parties can directly refer to, and interact with the same storybook that is presented in the child's physical environment.

In recent years, mixed reality has drawn increasing attention for novel pedagogical applications, with its promise to embed digital content within the user's physical environment [4]. Several research has compared MR-based book (e.g., MagicBook [5], Magic Story Cube [29]) to screen-based ebooks, and showed that MR systems could enrich children's learning experience by leveraging their awareness of the real world [8, 15]. Studies have also looked into the efficacy and engagement of MR books for children in the classroom [7, 12, 24] or co-located reading setup [8]. The results indicate that young participants agree with these augmented books' usefulness, effectiveness, and satisfaction.

Inspired by previous research, we see a promising opportunity of using an MR system for multi-generational interaction over distance. We hypothesize that an MR storytelling system with shared visual space superimposed in a physical environment will help promote high child engagement.

3 The "Let's Make a Story" System

3.1 Design Consideration

The "Let's Make a Story" system is designed with two key considerations to promote child engagement.

1) Supporting shared digital content within the child physical space: One of the key differences between a common video-conferencing and an in-person storytelling activity is that with the latter, both the family adult and the child can refer to the same content, *i.e.*, a storybook. We aim to bring the shared reading experience to our system by introducing shared digital book scenes, where both parties can see and refer to the same virtual scenes, story characters, as well as the actual physical environment where the child stays.
2) Promoting interactivity: Previous research has shown that mobile games have the potential to get children's attention better and facilitate learning objectives [6, 23]. Here, we plan to add interactivity to remote storytelling by introducing a series of events, or mini-games associated with different scenes of the story. For example, to make the story progress, the child will control the protagonist and has it directly interact with the story-related events. To further enhance the involvement and provide a playful experience, we consider adding tangibles and physical props as part of the system [19, 27].

3.2 System Overview and Interaction

The above considerations guide our final system design, which is also partially inspired by Raffle *et al.*'s work [2, 20]. Our system consists of two main components, a web-based client for the adult or parent, and a mobile phone application for the child. Both parties are located at a remote distance.

As in the traditional storytelling setup, we assume that the parent will be the primary narrator of a story. Thus, we provide the parent with the story captioning in the web-based client. To include shared story content (design consideration 1), the web client live-streams the virtual contents of the mobile application: *i.e.*, the parent can see both the virtual story scenes, the leading character of the story, the actual physical artifacts and the child's living environment, all captured from the child's mobile phone. To promote interactivity (design consideration 2), we include a list of mini-games relevant to the content of the story. These virtual events require the child to respond from the mobile end, but when to launch them are controlled by the parent (*e.g.*, placing visual guides and providing animations for story endings). In this way, the parent controls the story's pace and can engage the child with these mini-games at will (Fig. 4).

The mobile application is set with an MR experience to meet our design considerations. Specifically, we involve physical artifacts as part of the interactive experience. For a storytelling activity, we prepare a series of printed paper; each resembles one scene of a story (Fig. 3a). We ask the child to scan the printed paper using our mobile application, which generates a corresponding virtual 3D scene on the phone display. The virtual 3D scene is created with high-resolution 3D assets to offer visual graphics to the child, and is overlaid on top of the child's physical environment captured in real-time from the phone camera (Fig. 3c). While listening to the story from the parent, the child can manipulate the protagonist of the story within the virtual scene. As discussed in our design consideration 2, we hope to engage the child with additional tangible items as manipulative. Here, the manipulation of the protagonist is a physical can that can be commonly seen in a child's natural environment. The child can control the location and motion of the protagonist with the can; she can also control the protagonist to interact with events launched by the parent.

3.3 Implementation

Both the web-based client and the mobile phone application are implemented in Unity3D 2019 Engine. The communication and content sharing between the two applications uses typical TCP/IP protocol. Below we briefly summarize some of the key implementation details, including the pairing between physical and virtual assets, the screen-sharing between two applications, and how the child use can-manipulative to interact with virtual events.

Figure 2: The pairing between the digital and the physical uses Vuforia. a) Yellow crosses are the unique features for MR pairing. b) The image can be wrapped in a cylindrical shape. c) A can that is detected with the digital wolf attached to it. The image was created and licensed by Deviant Art [1].

Figure 3: Virtual scenes are generated from printed book papers. a) Printed book pages that were redesigned from Behance [2]. b) The child is scanning one of the printed book pages. c) Interactive virtual scene showed in the MR application. d-f) 3D Models were from Unity Asset Store [345].

3.3.1 MR Pairing

The virtual-real object pairing is achieved with Vuforia toolkits [17]. Specifically, for the can-protagonist pairing, we wrap printed paper around cans (seen in Fig. 2). These papers come with a cartoon drawing of the protagonist in the story. Unique features can be extracted from these cartoon drawings, which are used to register the virtual protagonist. Since the paper is wrapped around the can, as long as partial features can be observed from the phone, the virtual protagonist can be generated and tracked smoothly.

A similar idea is applied to the generation of the virtual scene as well. 3D scenes are registered to printed book pages (Fig. 3a and Fig. 3c). We post-processed book images by sharpening image edges to assure enough features (*e.g.* yellow crosses in Fig. 2a) can be detected and tracked [17].

For clear virtual content rendering, we exclude shadow effects in MR to avoid unexpected dark regions. We also modified the virtual content rendering queue in the shader to assure virtual protagonists are always rendered at the top.

3.3.2 Sharing Mobile Content

Sharing virtual contents between the child and the parent is achieved by streaming phone screens to the parent's application using Agora SDK [1] (Fig. 4). Although Agora is designed for building video chat applications, we re-proposed it to directly synchronize entire MR contents and interactions between the two clients.

3.3.3 Interacting with MR Events

We generate MR events or mini-games that match the story scenes. As one example, in a story where the protagonist needs to collect apples, the adult can 'drop' virtual apples into the virtual scene. The parent will ask the child to control the protagonist to 'collect' these apples.

The encounter detection of the can-manipulative with virtual assets is implemented with simplified collision detection mechanics with Axis-Aligned Bounding Box (AABB) in the screen space. In each time step, the bounding box is computed based on the mesh bounds of the virtual asset's 3D model and is projected into the screen space. In our system, only the position and rotation of the physical can is tracked in real-time. MR camera is fixed and performed as the world center, and thus the operation of projection for bounding boxes in each time step is quite efficient for further collision detection.

4 User Study

Due to COVID-19, all studies were conducted remotely with no local facilitators. In total, two story plots (Little Red, Wolf) and story conditions (MR vs. paper) are presented as within-subjects variables. Each adult-child pair read two stories in succession, one with our MR system and one with a similar paper-based story over video conferencing. To mitigate the effects of fatigue, the stories were kept short. While essentially similar, they were told from two different perspectives (Little Red, Wolf) to keep the second story interesting. Both stories were read by the remote adult. The order of paper and MR readings were counterbalanced as were the assignments of the two stories to either the paper or MR condition.

Like previous literature [20, 21], we measured the engagement

[1] Wolf Wrapper Image: https://www.deviantart.com/umbreonluvr/art/sad-anime-wolf-pup-212741093

[2] Little Red Book Cover: https://www.behance.net/gallery/9151145/Little-Red-Riding-Hood-(Book-Covers)

[3] Isometric Pack 3D: https://assetstore.unity.com/packages/3d/environments/fantasy/isome-tric-pack-3d-62262

[4] House Interiors: https://assetstore.unity.com/packages/3d/environments/fantasy/retro-dungeons-house-interiors-170705

[5] Werewolf Cute Series: https://assetstore.unity.com/packages/3d/characters/creatures/werewolf-cute-series-177868

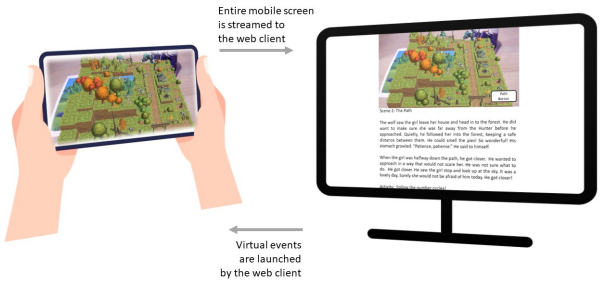

Figure 4: The mobile phone application streams the entire MR content to the parent's PC client. On the other hand, virtual events happening on the mobile application are launched from the PC.

using the time that is needed to finish the storytelling experience. We also collected children's preferences with the qualitative questionnaire (Fig. 6) designed according to the guidance of Smiley Face Likert scales [13]. In addition, we performed post-interviews with participants about their experience of using the MR system.

4.1 Participants and Procedures

We recruited eight participants with five boys aged between 6 and 9 and three girls aged 6, 7, and 9 from an online parents group. We specifically required that the child participant is between the ages of 5 and 11 and that the parent needed an Android phone. Participants were offered a thank-you gift of up to twenty-five dollars from an online food vendor. All participants were sent a consent form to review before the scheduled remote meeting. In this study, because the focus was on the child's experience with the MR system, the role of the remote adult was played by one of the experimenters to eliminate additional complexity and deliver a consistent reading experience across participants.

Both the "Little Red" and the "Wolf" stories are designed with three scenes. The MR activities include making the virtual story scene appear on the participant's phone, and summon the protagonist with the can. The child is free to play with the protagonist while the remote adult reads the text. Each story page ends with an MR mini-game, like"catch the bunnies," "follow the path," or "choose an action," depending on the story being told. At the end of the story's third page, the child is asked to create an ending. The child and the parent (if present) are followed with a short interview about their experiences at the end of the session. To provide a fair comparison, the paper story condition also has various mini-activities and a story ending activity for the child participant. As one example, the child will be asked to lift the paper flaps to find a hidden item (Fig. 5). The order of the story tasks is counterbalanced. Participants will have a short break between each of the story sessions. We recorded the entire study session for post-study analysis.

4.2 Results

To measure the child's engagement, we looked at the amount of time spent interacting with the story, the number of words that the child used in their creation of the story ending, and the results of a simple questionnaire asking which story the child enjoyed more. The degree of enjoyment was measured by the five-point happiness scale designed specifically for children participants [13]. For both the paper and MR experiences, the measured times represent the time the child was actually interacting with the story, excluding the time needed to address technical issues such as poor internet connection.

Figure 5: Printed book for the paper story condition. a): Each participant will print three book pages with one cut out assets which is used as b) paper flaps in mini-activities.

4.2.1 Quantitative Results

The quantitative result is summarized in Table 1. Note that for participant 5, the MR time represents a lower bound of the engagement time (detailed in the section 6).

Overall, the results show that the child participants chose to spend more time interacting with the MR experience. The results from participant 8 validate that the paper and MR experiences can take equivalent amounts of time, and participant 2 did finish the MR condition in less time than the average paper experience despite adding a longer than average story ending. Responses to the prompt to create a story ending were highly varied with longer endings being contributed by older children. For children who contributed longer dialog, the MR experience inspired more detailed responses, often describing what the Little red or the Wolf could do in the scene such as "then she hides under the bed and the wolf smashes the bed in half" from Participant 8. The shorter answers were more substantively similar despite the difference in words. For example, for the MR experience, participant 3 simply said "Attack!", which is a cue for the remote adult to initiate animation. The child smiled in response to the graphic but said nothing else. In contrast, at the end of the paper story participant 3 said "Um... I don't know, run," which is lengthier but may not reflect more engagement.

4.2.2 Qualitative Results

The questionnaire results showed that children uniformly preferred the MR experience and that they found it highly enjoyable, with 4.25 of the scale shown in Fig. 6. The most compelling indication that the MR experience was preferred, however, came from the post-hoc interviews and the subsequent unsolicited post-experiment communications from parents. Uniformly, children spontaneously had more comments about the MR experience: "That was epic!," "It

Table 1: Measured Results

Participant	Age	MR time	Paper time	AR Words	Paper Words	AR-paper time	AR-paper words	Preference	Enjoyment
1	6	7:13	3:56	15	20	3:17	-5	MR	3
2	9	4:22	2:37	93	36	1:45	57	MR	5
3	7	7:45	6:33	1	5	1:15	-4	MR	4
4	7	9:01	5:39	6	7	3:22	-1	MR	4
5	9	4:52*	3:15	63	11	1:37	52	MR	4
6	7	9:06	4:29	7	15	4:37	-8	MR	5
7	5	8:15	6:57	8	9	1:18	-1	MR	5
8	8	5:07	5:05	25	19	0:02	6	MR	4
sum	**7.25**	**6:58**	**4:49**	**27**	**15**	**2:09**	**12**	**MR**	**4.25**

Figure 6: The five choice scale used for children to assess their enjoyment of the story [13].

was cool," and "I like the game story." Their interest was also shown in comments to other family members: "Come see what the wolf looks like" (to a younger brother) and also in the suggestions on improvements to either experience: "I think you should put some wolf footprints on the path to show the wolf was there," "I would like grandma to join the story..what if grandma came in to join the story and maybe killed the wolf with a sword" and "I think you could make it like once you get the apples, you could have her mother there so that when she gets the apples she gives them to her mother."

Although the experience with the manipulative was often difficult to initiate, children seemed to find it a highlight of the experience: "I really like the whole thing where you move her by the can so I don't think that that should change" and "You could make it so that you could actually have a second can for the wolf so when the wolf shows up you can move the can." Only one parent suggested that the can might be replaced with buttons that the child could more easily control. After the experiment, we had one parent contacted us to thank us for the experience and said "It was SO FUN!" and another parent wrote write, "Just wanted to let you know my children enjoyed this phone game and right now my 5 year old one is just trying to mimic the same game with his own story (The bunny wolf) :)."

5 Discussion and Limitations

In this section, we discuss challenges for the development of our sharing AR system and the setup of user study with remote families, followed by viable solutions.

6 Discussion and Limitations

This study comprised a limited number of participants in a variety of remote settings—differences in participants' environments and the degree of parental involvement in the experience that were difficult to control. Some children were shyer with respect to being participants in the study, which may have limited the extent to which quantitative assessment of story generation reflected their interest in the game. Additionally, there were technical issues with both the paper and MR experiences under remote cooperation environments. In several cases, parents had failed to assemble the paper book properly (flaps had to be fixed in certain places and paper characters had to be cut out and ready for use), and in several other cases, the MR application either lost connection or crashed for unknown reasons. In an extreme case, for participant 5, the MR story crashed three times after progressing through only the first or the first and second scenes. On the fourth attempt, the dialog was omitted from the first and second scenes to mitigate story fatigue, and the child simply played through scenes one and two. The dialog was resumed when the child reached the third scene. For each recording, a third-party rater who was not involved in the user study assessed how much of the total time the child spent actually engaging with either the paper or MR story material.

6.1 Challenges of the Remote User Study

Our remote study had a number of challenges. These included home environmental variables such as lighting conditions and the number of other people present in the room. Additionally, although every effort was made to simplify the preparation instructions and minimize the burden of participation for the study, it was still a considerable effort for parents to assemble all the materials— for example, creating the manipulative using an empty, dry 12oz can, and cutting out the paper flaps and characters for the paper book.

We also needed to ensure that the MR experience was compatible with the user's phone, so we collected phone model data and created custom exports of the app that were listed as suitable for their model by the emulator. Each participant was given a Google doc with specific instructions and links for their experience and presentation order and for a link for the .apk that would specifically work with their phone. For example, if a participant was assigned "Paper Little Red" then "AR Wolf" as their study conditions, the instructions would only include those options and a link to an MR Wolf application compatible with their phone. Because phone compatibility and lighting were known issues from a pilot study [26], we created a test mode that allowed users to test the app and augmented character generation in advance of the study.

We additionally identified that it was often difficult for the child to hold the phone in one hand and manipulate the can with respect to the phone without some practice. The can has to be held in a way that does not obscure the picture and sufficiently far from the phone for the character to generate. We addressed this challenge by having a specific list of instructions for the child to follow regarding how to hold the can. We also developed the strategy of first placing the phone on a flat surface so that the child would simply have to focus on aiming the phone at the can to get the character to generate. Many children found this to be a preferred way of interacting with the character (seen in Fig. 1d). In a lab setting, we could have facilitated this issue by providing in-person instruction and demonstration of the manipulative and providing phone support so that the child would have the option of just focusing on manipulating the can.

7 Conclusion

In this paper, we present a unique mixed reality story experience for children that allows remote adults to both see their loved child and co-experience story-related gameplay with the child. The remote adult is a necessary partner in the gameplay, enabling mini-game action by providing the child with necessary items to complete the scenes. In our user study, we found that children spent more time with the MR story compared to a similar paper activity book, and used more words in the formation of an optional story ending. More descriptive stories often incorporated details from the AR scene where as the paper story endings did not refer to the pictures or artifacts in the paper activity book. In our simple questionnaire, the child participants all agreed that they preferred the MR experience. Parents also expressed enthusiasm for the system in post-hoc unsolicited communications. We believe that our system has the potential to create engaging, collaborative, cross-generational remote experiences that both adults and children will love.

Acknowledgments

The authors wish to thank the anonymous reviews and the artists who created great models and textures in Unity Asset Store.

References

[1] Agora.io video, voice and live interactive streaming platform. Accessed: 2010-02-19.

[2] M. G. Ames, J. Go, J. J. Kaye, and M. Spasojevic. Making love in the network closet: The benefits and work of family videochat. In *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative*

Work, CSCW '10, p. 145–154. Association for Computing Machinery, New York, NY, USA, 2010. doi: 10.1145/1718918.1718946

[3] R. Ballagas, J. Kaye, M. Ames, J. Go, and H. Raffle. Family communication: phone conversations with children. In *Proceedings of the 8th international Conference on Interaction Design and Children*, pp. 321–324, 2009.

[4] M. Billinghurst and H. Kato. Collaborative mixed reality. In *Proceedings of the First International Symposium on Mixed Reality*, pp. 261–284, 1999.

[5] M. Billinghurst, H. Kato, and I. Poupyrev. The magicbook: a transitional ar interface. *Computers & Graphics*, 25(5):745–753, 2001.

[6] P. Blewitt and R. Langan. Learning words during shared book reading: The role of extratextual talk designed to increase child engagement. *Journal of Experimental Child Psychology*, 150:404–410, 2016.

[7] Y.-J. Chang, C.-H. Chen, W.-T. Huang, and W.-S. Huang. Investigating students' perceived satisfaction, behavioral intention, and effectiveness of english learning using augmented reality. In *2011 IEEE International Conference on Multimedia and Expo*, pp. 1–6. IEEE, 2011.

[8] K.-H. Cheng and C.-C. Tsai. Children and parents' reading of an augmented reality picture book: Analyses of behavioral patterns and cognitive attainment. *Computers & Education*, 72:302–312, 2014.

[9] A. Forghani and C. Neustaedter. The routines and needs of grandparents and parents for grandparent-grandchild conversations over distance. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '14, p. 4177–4186. Association for Computing Machinery, New York, NY, USA, 2014. doi: 10.1145/2556288.2557255

[10] S. R. Fussell, R. E. Kraut, and J. Siegel. Coordination of communication: Effects of shared visual context on collaborative work. In *Proceedings of the 2000 ACM conference on Computer supported cooperative work*, pp. 21–30, 2000.

[11] D. Gergle, R. E. Kraut, and S. R. Fussell. Using visual information for grounding and awareness in collaborative tasks. *Human–Computer Interaction*, 28(1):1–39, 2013.

[12] T. Glenn, A. Ipsita, C. Carithers, K. Peppler, and K. Ramani. Storymakar: Bringing stories to life with an augmented reality & physical prototyping toolkit for youth. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pp. 1–14, 2020.

[13] L. Hall, C. Hume, and S. Tazzyman. Five degrees of happiness: Effective smiley face likert scales for evaluating with children. In *Proceedings of the The 15th International Conference on Interaction Design and Children*, pp. 311–321, 2016.

[14] J. Holmes. Hello–goodbye: An analysis of children s telephone conversations. 1981.

[15] E. Hornecker and A. Dünser. Of pages and paddles: Children's expectations and mistaken interactions with physical–digital tools. *Interacting with Computers*, 21(1-2):95–107, 2009.

[16] T. K. Judge and C. Neustaedter. Sharing conversation and sharing life: video conferencing in the home. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 655–658, 2010.

[17] J. Linowes and K. Babilinski. *Augmented reality for developers: Build practical augmented reality applications with unity, ARCore, ARKit, and Vuforia*. Packt Publishing Ltd, 2017.

[18] C. Neustaedter, K. Elliot, and S. Greenberg. Interpersonal awareness in the domestic realm. In *Proceedings of the 18th Australia conference on Computer-Human Interaction: Design: Activities, Artefacts and Environments*, pp. 15–22, 2006.

[19] S. Price, Y. Rogers, M. Scaife, D. Stanton, and H. Neale. Using 'tangibles' to promote novel forms of playful learning. *Interacting with computers*, 15(2):169–185, 2003.

[20] H. Raffle, R. Ballagas, G. Revelle, H. Horii, S. Follmer, J. Go, E. Reardon, K. Mori, J. Kaye, and M. Spasojevic. *Family Story Play: Reading with Young Children (and Elmo) over a Distance*, p. 1583–1592. Association for Computing Machinery, New York, NY, USA, 2010.

[21] H. Raffle, G. Revelle, K. Mori, R. Ballagas, K. Buza, H. Horii, J. Kaye, K. Cook, N. Freed, J. Go, and M. Spasojevic. Hello, is grandma there? let's read! storyvisit: Family video chat and connected e-books. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '11, p. 1195–1204. Association for Computing Machinery, New York, NY, USA, 2011. doi: 10.1145/1978942.1979121

[22] N. Romero, P. Markopoulos, J. Van Baren, B. De Ruyter, W. Ijsselsteijn, and B. Farshchian. Connecting the family with awareness systems. *Personal and Ubiquitous Computing*, 11(4):299–312, 2007.

[23] M. Sharples, D. Corlett, and O. Westmancott. The design and implementation of a mobile learning resource. *Personal and Ubiquitous computing*, 6(3):220–234, 2002.

[24] A. K. Sin and H. B. Zaman. Live solar system (lss): Evaluation of an augmented reality book-based educational tool. In *2010 International Symposium on Information Technology*, vol. 1, pp. 1–6. IEEE, 2010.

[25] K. Tee, A. B. Brush, and K. M. Inkpen. Exploring communication and sharing between extended families. *International Journal of Human-Computer Studies*, 67(2):128–138, 2009.

[26] D. Wang, J. Healey, J. Qian, C. Wigington, T. Sun, and H. Peng. Lets make A story measuring MR child engagement. *CoRR*, abs/2104.06536, 2021.

[27] L. Xie, A. N. Antle, and N. Motamedi. Are tangibles more fun? comparing children's enjoyment and engagement using physical, graphical and tangible user interfaces. In *Proceedings of the 2nd international conference on Tangible and embedded interaction*, pp. 191–198, 2008.

[28] S. Yarosh, S. Cuzzort, H. Müller, and G. D. Abowd. Developing a media space for remote synchronous parent-child interaction. In *Proceedings of the 8th international Conference on interaction Design and Children*, pp. 97–105, 2009.

[29] Z. Zhou, A. D. Cheok, J. Pan, and Y. Li. Magic story cube: an interactive tangible interface for storytelling. In *Proceedings of the 2004 ACM SIGCHI International Conference on Advances in computer entertainment technology*, pp. 364–365, 2004.