Sally&Molly: A Children's Book with Real-Time Multiplayer Mobile Augmented Reality

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ABSTRACT

The book 'Sally&Molly' is for children aged five to ten, a phase where children transition from a self-centered view of the world to social understanding. Via mobile AR we offer a second layer to the book and playful activities with it. We describe the design and design rationale, and explore cooperative real-time multiplayer mechanics for children in mobile AR.

CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; **Collaborative and social computing theory, concepts and paradigms**; *Ubiquitous and mobile computing design and evaluation methods*;

KEYWORDS

AR Gaming, Game Design, Augmented Book, Reading, Play

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1 INTRODUCTION

The project Sally&Molly focuses on game design for children in a real-time, multiplayer, mobile handheld AR video game. This was developed in two stages. The first relates to characters and narrative creation; it focused on the creative development of the traditional, physical book and its story, including play mechanics. The second stage enhances this with a technology layer. Developing the book in stages enables us to distribute and test a version that in itself is complete and has permanent value for its users. As the physical book is available for purchase, this also simplifies user testing with a global user base, as participants of studies only need to download the game app.

There are several reasons for choosing a see-through augmented reality (AR) approach with a physical book as a base instead of purely virtual game play. The project's main aim is mobile gameplay that is appropriate and healthy for children's transition from the pre-operational to concrete operational period [16]. We take into consideration different views regarding children's development concerning technology [12, 14] and video game experience design. The video games for health movement [4] proposes to design for positive, healthy benefits. However, it has been debated that this view lacks emphasis on the spectrum of human emotion that video games can elicit [7, 18]. Playground design research [5] identified a fruitful overlap between these perspectives, and argues for a holistic view on the range of decision making in play activities: for their development, children need physical, emotional and intellectual stimuli in the full range possible. With our approach, a physical book can encourage bodily experiences which are beneficial for playing [21, 24], gives ownership to children, and can easily be socially shared, fitting into common parent-child reading patterns and roles. Moreover, with Sally&Molly, social gaming can transition from a single play 'local' activity to shared play and remote multiplayer game play.

In this work in progress, we develop and preliminary tested a demo application that showcases the possibilities of an AR for single-play and cooperative multiplayer play mechanics in different play scenarios using the book.

2 AR FOR CHILDREN

The idea for AR books has been around for a considerable time [6, 10, 22]. Advances in ubiquitous mobile technologies have now made AR accessible for large audiences. The research classification made in 2016 by Altınpulluk and Kesim [3] needs an update since there has been a considerable amount of new investigation in the five years since. However, there is still not much work on AR Books with real-time multiplayer experiences. Instead, among other topics, environment mapping is investigated for multiplayer experiences, as with EmoFindAR[19].

With the new technologies, one could think that AR Books are a thing of the past. However, people still enjoy physical books, sometimes because of their print quality, physicality (material qualities), and being able to own them [13, 20, 23]. Studies on AR and children's development [9] mention social and physical benefits. For instance, Pokemon-Go allows children to participate in group activities and provides shared topics for interacting in groups [9]. Studies have found that children quickly understand AR overlays on books, that they need clear feedback on progress or 'success signals', and that age-appropriate choice of story and interaction are important [10]. As AR books are still novel for consumers and younger children, there is still much to be explored and researched. The technologies allow new forms of social play with a physical object in real-time, introducing novel and healthy ways of socialization in video games for younger children.

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Figure 1: A1) Mock-ups of the book, A2) Draft book cover, A3) Sally&Molly final cover art

3 SALLY&MOLLY - THE BOOK AND ITS DESIGN

In the first development phase, the backstory, narrative and characters for the book were developed (fig. 1). The physical book was developed in 2016 by the first author in collaboration with artist Catalina Corvalán, illustrator and creator of the comic series "La colina de los Tordos" and "La brujita vampiro". Sally&Molly was published in a small print-run in 2018, and is currently being localized to three languages.

The book mixes and interleaves elements of narrative books and the "Where is Waldo?" puzzle books. The latter feature a character that is to be found, but lack a narrative that motivates the search activity. Interleaving the two provides children with a dedicated task, alternating reading with play activity, which also gives an adult (who might read with the child) a break from reading aloud and allows the adult and child to recover and re-engage in reading.

The book tells the story of Molly, a little girl who needs to find her cat. The cat Sally shares a common habit of cats; they escape and sometimes hide. These two characters drive the narrative and search mechanics of the book and game. There is a second level of meaning in teaching about caring for an animal. The cat has a life of its own, cannot be possessed like an object, but shares space with people it trusts and that feed it.

Text is limited to one paragraph of text on each normal story page, and one paragraph on each search double-page, to support focus on the search action. Verse style writing is used to make reading engaging and memorable for parent and children. It provides a rhythm that makes the text easy to read out and listen to. The narrative and art style are simple and classic to give longevity to the book. Illustrations in watercolor are timeless; this medium with a contemporary drawing style combines rich detail (that adults can appreciate) and a visual style suitable for children. The story provides a meaning and goal for the search activity.

The book design explores elements of video game mechanics related to the 'hidden object' type. The search pages become increasingly difficult so that more time is needed to find the cat in the scenes. The scenes become complex via two main factors: number of objects on a page and similarities of objects in form and color to the search subject (fig. 2 A.2, A.3). The final result is a children's book of 46 pages, with four pages showing double-page search scenes containing vibrating watercolor art with characters and narratives designed to keep children's engagement.

3.1 Mobile AR Technology Implementation

The AR overlay application was developed with the Unity3D game engine [2], the Photon software development kit (SKD)[11] and their cloud system for real-time multiplayer functionality. We tested two SDKs for AR: Vuforia [8], which has a marker-based tracking technology, and ARCore [1], which combines sensor and image tracking functionalities for simultaneous localization and mapping (SLAM). We aim to explore different mobile platforms, beginning with the most widely available smartphones. Currently, we have tested the application in smartphones with Android operative system (OS).

4 SALLY&MOLLY - THE AR GAME DESIGN

The AR game works with the existing book and characters. Here, we utilize the hidden object game mechanic. This type of games is made in 2D and normally uses touch or click interaction to point at the object to be found. As we use AR marker-based technology, we developed 3D search scenes built on top and using the elements of the search scenes from the book (fig. 2). The search is done with a 'token' (fig. 3), a representation of the user's cursor in form of a light column shown in the AR view. This moves as the phone moves over the page. It is projected into the scene by a ray trace that collides with the ground of the AR scene (fig. 3 B). The search item is depicted above the token; once the token is above the right image, feedback in form of twinkling stars appears. The player is informed whether there are more items to be searched for, and with each found item, the progress bar on the token rises, as shown in fig. 3 A.

Figure 2: A.1) Children's searching for Sally in search scene in the book, A.2) First search page, A.3) Last search page

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This interaction was chosen based on previous observation of children's smartphone interaction, where movement plus gaming was difficult for children, who had trouble to hold a phone steadily, interfering with touch input. Therefore, the play interaction only requires moving the token onto the item to be found (fig. 5). The app is deliberately simple to avoid common issues often found in commercial games (making interaction too restricted for children or having them too focused only on the main interaction). Moreover, young children need a predictable and consistent relation between action and effect and they love repetitive actions [14]. Our chosen game pattern of repeated search for the cat addresses this.

4.1 AR Layer

First, the child chooses their color for the token, which later enables distinguishing their own token from other players. The token is the pointer in the game; it shows how many items to find, and the specific item to search (fig. 3). Next, a short tutorial scene is played through. In a basic scene it is easier to learn how to move the token and to relate the token search item to the one in the scene. Then, the new scene is loaded and the game begins (it is planned to allow for de-activating and re-activating the tutorial phase in the app, since this is only needed when a child first uses the AR app).

The 3D AR views are based on the 2D illustrations from the book, and created from textured planes creating a similar effect to a 3D pop-up book (fig. 3 B.3). Specific elements in the scenes are created in 3D models to balance the 2D flat effect that this technique can sometimes generate.

In the app design, we avoided static user interface (UI) screen elements during game play, instead all information is added to and integrated in the token (fig. 3). The token's minimalist design reminds of player's tokens in board games. Tokens only mark the player's position on the board but still include a moment of choice by picking their favorite color. We decided not to represent this via an avatar, as the use of narrative avatars has the child impersonate the character [15]. Whereas with a simple token we intend to make the child aware of itself in the game, and to connect other tokens to other people.

4.2 Single Player versus cooperative Multiplayer Mode

The current demo version starts in single-player mode. It can be played autonomously, but parental help might be helpful depending on the child's development [17]. If game design supports children's development, creating a game to be played entirely autonomous to the point that a parent is never involved is not a good practice. We know that children need to interact with and to learn from their peers or parents for their development [17].

In the demo, the goal is to find three random-chosen items in the search scene on the book cover, which introduces the game mechanics in a simplified environment. Each time an item is found, there is a positive feedback sound and animation, and the progress bar on the tokens grows (fig. 5 A). The expected behavior for the child is to move back and forth on the page with the smartphone since the pointing interaction is more precise at a closer range.

The point and search mechanic is implemented by having the child point with the entire phone (fig. 5), not requiring touch interaction; this enables the child to use both hands to hold the phone. We encourage body movement in play since pointing is related to the smartphone position, rotation, and direction in space; this also opens possibilities to game design related to bodily experiences, which can be beneficial to the experience of play [14, 21, 24]. A ray trace shoots forward from the virtual camera aligned to the user's phone position according to the marker (fig. 5 A2); when the ray trace crosses the ground of the search scene, this point is saved, and the token moves in linear speed towards the new position (fig. 5 A3). When the ray trace crosses an object, there is an animation toward the search item and the token at the center of it. The app checks if the object is the one searched for. If yes, the progress marker moves one notch upwards, particle animation is shown, and a positive feedback sound is played (fig. 3 B2).

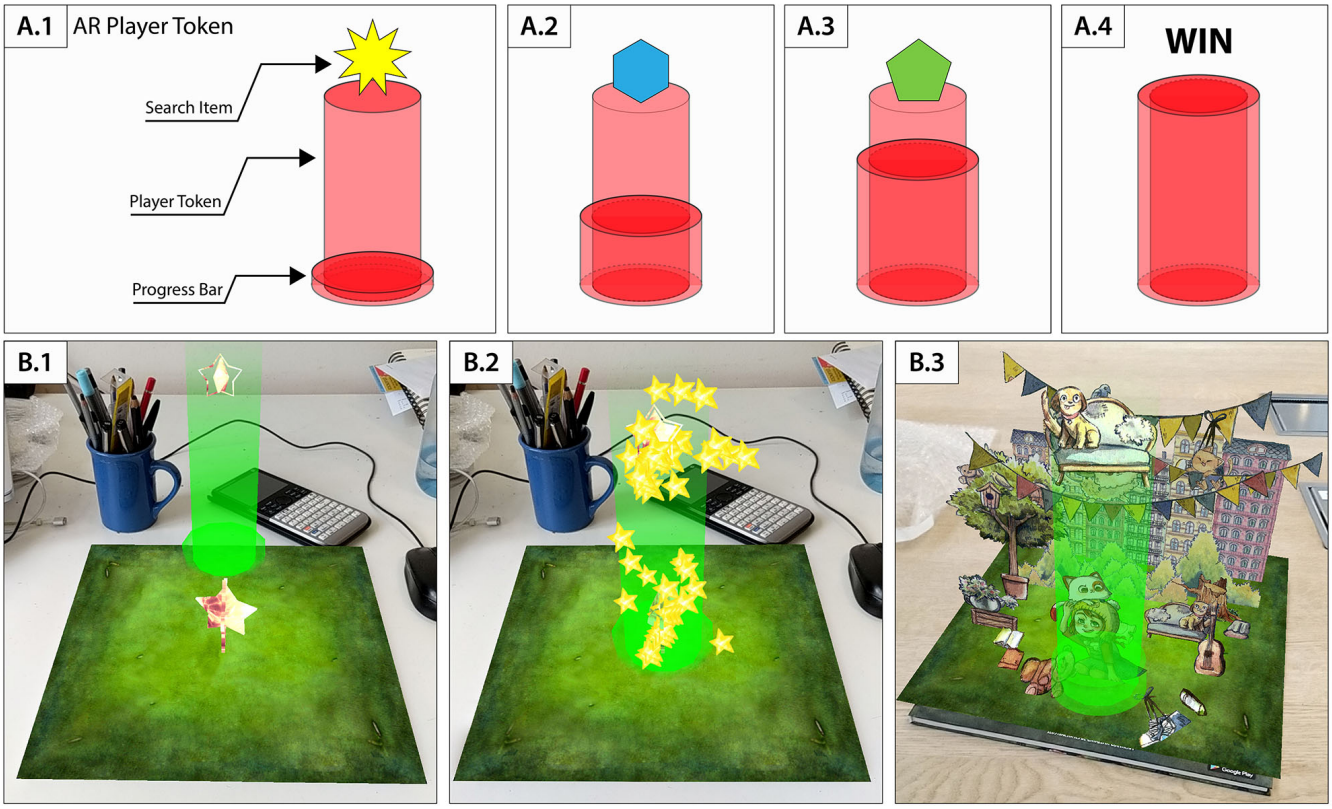

Figure 3: A) Token design and stages of search for three hidden objects in succession, with the progress bar rising up on the token. B) Smartphone screen shots of token in AR scene B1) Token on tutorial scene, B2) Reward animation when search item is found, B3) Token on the actual book cover scene.

Figure 4: Children looking at the book with AR on a phone.

The cooperative play mode has the same core mechanics as single play, but now both players need to point at the search item at the same time to move forward in the game. This change is subtle, but opens lots of possibilities regarding how to play together. As the game happens in real time, each player can see each other's token in the game environment. Playing locally in the same space, children

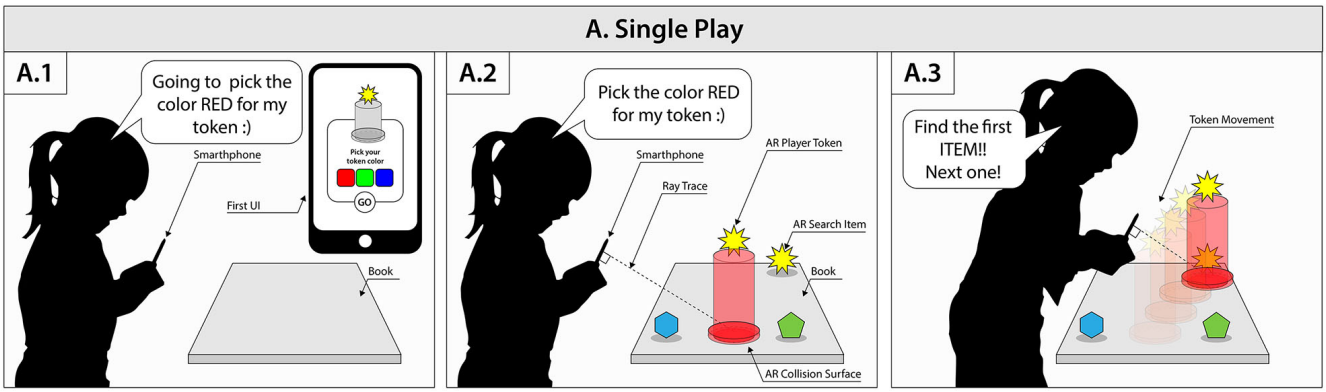

Figure 5: Play elements and token movement. A1) Token color UI, A2) Ray trace for token placement, A3) Token movement

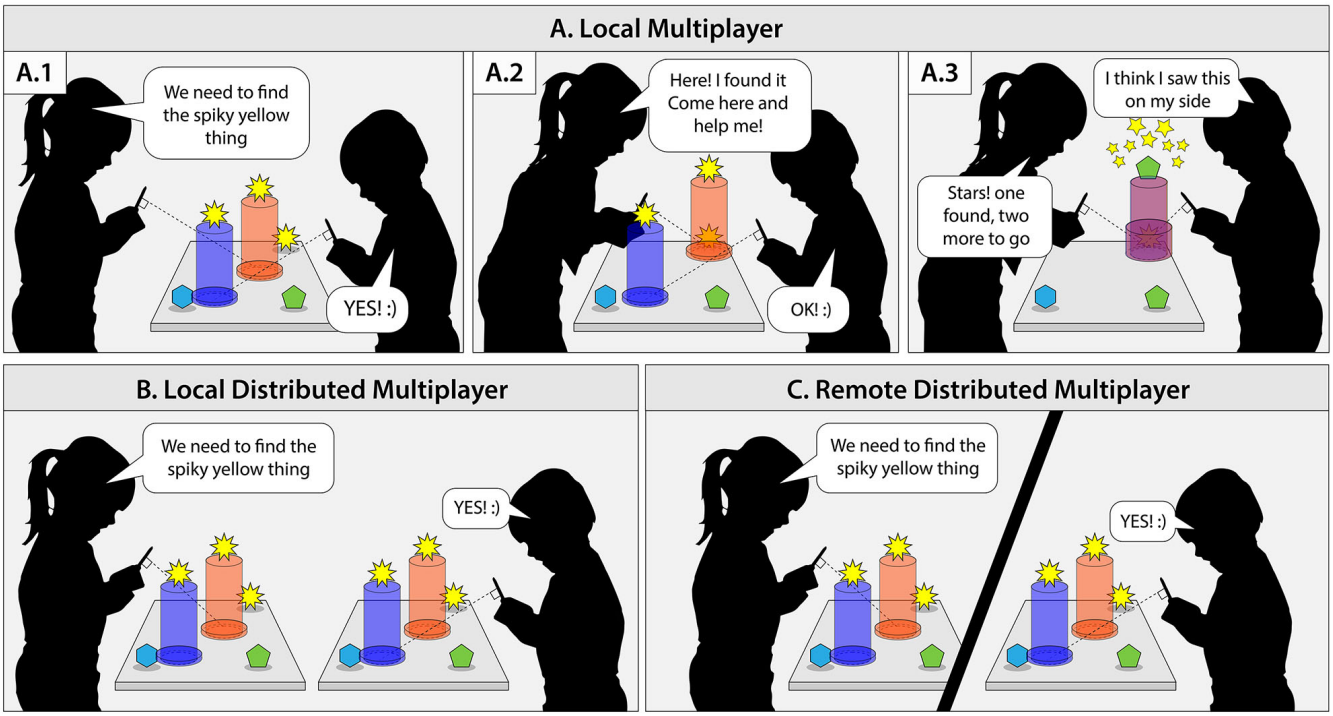

Figure 6: Multiplayer cooperative play, A1) Local play: one book in same space, B) Local distributed play: two or more books in same space, C) Distributed remote play: two or more books in different places.

can share one book, and play in a shared space (fig. 6 A). This may sometimes create issues, for instance, some search items are difficult to point to from more than one direction without getting into each other's way, so both players will need to compromise how to hold their phones in a narrow corridor to point at the item. While posing a challenge, this may also train social coordination as well as motor skills. A positive effect of local play is that communication can flow naturally since both players are in the same space. Local distributed play requires two books. Each child can use their own book in a common physical space and will need to coordinate flipping the pages and timing of search. They can even shift between searching in the same book and using both (fig. 6 B). Distributed remote play is the last stage of social cooperative play. In this case, it is recommended to also have a phone call for an audio communication channel. In this case, each child plays in their own home with their own book (fig. 6 C).

5 OBSERVATIONS FROM PRELIMINARY TESTING

We tested the book in the order of stages it should be used. A preliminary test was done in two different situations, one with

three children from four to six year and one parent, and other with one child of six years and one mother. This was conducted in each family home with the children and the parents, with one researcher as observer present. Only minimal help and guidance were given, and the trial was recorded via video and photography. After the test, we conducted an open interview to share their opinions of the complete experience. After the test, the book and application stayed with the families; after two weeks, there was a video conference for a final interview.

1) Book reading and search: The big size makes the book easy to share among three to four kids; also, some children even lean on the book while trying to find the cat in the cover (fig. 4). From the parent's perspective, the reading in verse was beneficial to keep the child's attention and increase memorability. Some children memorized specific phrases related to images, and could repeat those even after two weeks when looking at the illustrations. A father mentioned how nice the watercolor and the analogue feel of the book was. An unexpected behavior was non-linear reading; parents read some pages and stayed for an extended time on a search page. In the following reading, they came back to a previous search scene and continued reading from there.

2) Single play: This gave the book a second use as expected. The parents used the AR after reading in occasions, also the kids would request to play with the AR scenes, a children of fours years asked to see the AR scenes before going to sleep. It was reported to us that a five-year-old said to his mother that he wanted to use the "Magic" (Yilmaz et al. also mention this [26], showing how children perceive AR technology). Some parents had to help their children use the application initially, but they learned this in three to four tries. The input and mechanics were learned fast for children from 5 to 6 years. As designed, kids had to move the phone further back to be able to see the token and the search item in the token. Sometimes they also moved the book itself back and forth. One issue for younger children was holding the phone properly and stable.

3) Multiplayer: Children were eager to play with others; looking at the different tokens shown on the screen made them wonder about their own movement in the game and made them ask to look at their parent's screen to see the relation of movement to theirs in other screen. When testing the distributed play mode, a messenger app (Whatsapp) was used as a verbal communication channel while playing; this make the playing more fun and chaotic. There was some confusion for the first 5 minutes; and after a while, the children invented and played their own games, for instance, catching their co-players token.

6 CONCLUSIONS AND FUTURE WORK

We reported on our work on Sally&Molly, a children's book enhanced with novel AR and real-time multiplayer functionalities. The focus of the project is to create a healthy and age-appropriate approach for children's social gaming. We presented the first part of the technology enhancement of the book and possible interactions that can support children's transitioning to social gaming experiences. Moving forward, we will iterate the current version to become fully functional across the entire book; we will implement functionality to find the cat in each search scene aligned with the narrative of Sally&Molly, add multiple positions for the cat in each search scene to avoid memorization and allow reusability - after the cat has been found there will be an option to find other items which are common in search books. We will further develop our understanding of what it means to create healthy gaming experiences for children and create a better transition from a personal to social view of the world in social experiences. In further development, we aim to include co-creation with our users designing with and for parents [14, 25], and to develop game mechanics that offer different roles for them, so they can have a dedicated role and actively participate in the experience with their children. A focus will be on mechanics centered on experiencing the body as play [21]. Other opportunities concern competitive play versus cooperative team modes. There is still lots to be done in testing the different possibilities of Sally&Molly multiplayer experience.

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REFERENCES

[1] Google. 2008. *ARCore, build new augmented reality experiences that seamlessly blend the digital and physical worlds.* Google, Unite Stated. https://developers.google.com/ar

[2] Unity Technologies. 2005. *Unity is a cross-platform game engine developed by Unity Technologies.* Unity Technologies., Unite Stated. https://unity.com/

[3] Hakan Altınpulluk and Mehmet Kesim. 2016. The classification of augmented reality books: A literature review. *INTED2016 Proceedings* 48 (2016), 4110–4118.

[4] Tom Baranowski, Fran Blumberg, Richard Buday, Ann DeSmet, Lynn E Fiellin, C Shawn Green, Pamela M Kato, Amy Shirong Lu, Ann E Maloney, Robin Mellecker, Brooke A Morrill, Wei Peng, Ross Shegog, Monique Simons, Amanda E Staiano, Debbe Thompson, and Kimberly Young. 2016. Games for Health for Children-Current Status and Needed Research.. In *Games for health journal.* Games for health journal, 1–12. https://doi.org/10.1089/g4h.2015.0026

[5] Ann C. Barbour. 1999. The Impact of Playground Design on the Play Behaviors of Children with Differing Levels of Physical Competence. *Early Childhood Research Quarterly* 14 (1999), 75–98.

[6] M. Billinghurst, H. Kato, and I. Poupyrev. 2001. The MagicBook - moving seamlessly between reality and virtuality. *IEEE Computer Graphics and Applications* 21, 3 (2001), 6–8. https://doi.org/10.1109/38.920621

[7] Max Birk, Ioanna Iacovides, and Daniel Johnson. 2015. The False Dichotomy between Positive and Negative Affect in Game Play. In *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play* (London, United Kingdom) *(CHI PLAY '15)*. Association for Computing Machinery, New York, NY, USA, 799–804. https://doi.org/10.1145/2793107.2810258

[8] Qualcomm company. 2008. *Vuforia Engine to build Augmented Reality Android, iOS, and UWP applications for mobile devices and AR glasses.* PCT, Unite Stated. https://developer.vuforia.com/

[9] Prithwijit Das, Meng'ou Zhu, Laura McLaughlin, Zaid Bilgrami, and Ruth L. Milanaik. 2017. Augmented Reality Video Games: New Possibilities and Implications for Children and Adolescents. *Journal of multimodal technologies and interactio* (2017).

[10] Andreas Dünser and Eva Hornecker. 2007. An Observational Study of Children Interacting with an Augmented Story Book. In *Technologies for E-Learning and Digital Entertainment*, Kin-chuen Hui, Zhigeng Pan, Ronald Chi-kit Chung, Charlie C. L. Wang, Xiaogang Jin, Stefan Göbel, and Eric C.-L. Li (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 305–315.

[11] Exit Games Photon. 2021. *Photon Realtime is a base layer for multiplayer games and higher-level network solutions. It solves problems like matchmaking and fast communication with a scalable approach.* Exit Games Photon, Unite Stated. https://www.photonengine.com/en-US/Photon

[12] Heléne Gelderblom and Paula Kotzé. 2009. Ten Design Lessons from the Literature on Child Development and Children's Use of Technology. In *Proceedings of the 8th International Conference on Interaction Design and Children* (Como, Italy) *(IDC '09)*. Association for Computing Machinery, New York, NY, USA, 52–60. https://doi.org/10.1145/1551788.1551798

[13] Taejin Ha, Youngho Lee, and Woontack Woo. 2010. Digilog book for temple bell tolling experience based on interactive augmented reality. *Virtual Reality* (2010).

[14] Michaela Honauer, Preetha Moorthy, and Eva Hornecker. 2019. Interactive Soft Toys for Infants and Toddlers - Design Recommendations for Age-Appropriate

Play. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '19)*. Association for Computing Machinery, New York, NY, USA, 265–276. https://doi.org/10.1145/3311350.3347147

[15] Katherine Isbister. 2016. *How Games Move Us: Emotion by Design.* The MIT Press.

[16] Muhammad Farooq Joubish and Muhammad Ashraf Khurram. 2011. Cognitive Development in Jean Piaget's Work and its Implications for Teachers. *World Applied Sciences Journal* 12 (2011), 1260–1265.

[17] Alexis Leontiev, Alexander Romanovich Luria, and Lev Semenovich Vigotsky. 2007. *Psicología y pedagogía Luria, Leontiev, Vigotsky.* Akal, S.A, Sector Foresta 1. Madrid España, Name of chapter: LS Vigotsky, aprendisaje y desarrollo intelectual en la edad escolar), 23–39.

[18] Conor Linehan, Sabine Harrer, Ben Kirman, Shaun Lawson, and Marcus Carter. 2015. Games Against Health: A Player-Centered Design Philosophy. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (Seoul, Republic of Korea) *(CHI EA '15)*. Association for Computing Machinery, New York, NY, USA, 589–600. https://doi.org/10.1145/2702613.2732514

[19] Lissette López-Faican and Javier Jaen. 2020. EmoFindAR: Evaluation of a mobile multiplayer augmented reality game for primary school children. *Computers & Education* 149 (2020), 103814. https://doi.org/10.1016/j.compedu.2020.103814

[20] Catherine C. Marshall. 2005. Reading and Interactivity in the Digital Library: Creating an experience that transcends paper. In *In Proceedings of CLIR/Kanazawa Institute of Technology Roundtable*. 20 pages.

[21] Florian 'Floyd' Mueller, Richard Byrne, Josh Andres, and Rakesh Patibanda. 2018. *Experiencing the Body as Play.* Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3173574.3173784

[22] Tomoki "Issac" Saso, Kenji Iguchi, and Masa Inakage. 2003. Little Red: Storytelling in Mixed Reality. In *ACM SIGGRAPH 2003 Sketches & Applications* (San Diego, California) *(SIGGRAPH '03)*. Association for Computing Machinery, New York, NY, USA, 1. https://doi.org/10.1145/965400.965573

[23] Abigail J. Sellen and Richard H.R. Harper. 2003. *The Myth of the Paperless Office.* MIT Press, Cambridge, MA, USA.

[24] Orit Shaer and Eva Hornecker. 2010. Tangible User Interfaces: Past, Present, and Future Directions. *Found. Trends Hum.-Comput. Interact.* 3, 1–2 (Jan. 2010), 1–137. https://doi.org/10.1561/1100000026

[25] Brigitte Vittrup, Sharla Snider, Katherine K Rose, and Jacqueline Rippy. 2016. Parental perceptions of the role of media and technology in their young children's lives. *Journal of Early Childhood Research* 14, 1 (2016), 43–54. https://doi.org/10.1177/1476718X14523749 arXiv:https://doi.org/10.1177/1476718X14523749

[26] R. Yilmaz, Sevda Kucuk, and Y. Goktas. 2017. Are augmented reality picture books magic or real for preschool children aged five to six? *Br. J. Educ. Technol.* 48 (2017), 824–841.