Children’s Use of Virtual Reality During the COVID-19 Pandemic

Elise Most, M.A. Candidate

Stanford Dept. of Communication

Advisor: Professor Jeremy Bailenson

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Socially distanced learning became a household term during this past year due to the COVID-19 global pandemic. Children’s education across the world was severely disrupted beginning in March 2020 following extended and repeated lockdowns. Many schools have since resorted to online or hybrid learning systems, and many are only just planning for a return to fully in-person schooling in fall 2021. The importance of having systems in place to ensure learning continuity will only increase as the potential for the spread of deadly disease rises along with the expansion of human activities (Chin et al. 2). In addition, the uncertainty of the present moment begs the question, how dependent on distance learning will we be in the future?

One method of remote instruction that necessitates further study is that of virtual reality. While VR is still a relatively niche, expensive form of media that has yet to reach a broad portion of the population, it merits conversation due to its significant educational potential. Its immersive nature may help prepare students for real-life experiences, such as public speaking, and it grants them up-close access to remote or inaccessible locations with historical, cultural, or scientific significance, such as ancient Egyptian tombs, the Antarctic, or the ocean floor. Students may use VR to complete lab assignments—for example, exploring human anatomy—which would be infeasible in real life due to lack of resources or ethical reasons. Popular applications such as “Beat Saber” or “Supernatural” provide intense workouts that could help users stay in shape during lockdowns, and can supplement physical education classes. Virtual reality may also aid in making learning more accessible for students with disabilities. If it becomes common, it may present a potential new world of opportunity for many disadvantaged students around the world.

My contribution to the study of virtual reality examines how children used it in the home during the first few months of the global COVID-19 pandemic and the height of the lockdown orders. This was a one-of-a-kind opportunity to delve into the ways people interact with VR, as
well as what work needs to be done to improve its reach and effectiveness as a teaching tool. Other studies tend to focus on the use of media in general during the pandemic, or on the use of media—social media in particular—during other historical disasters. We gained vital information surrounding childrens’ VR use patterns and application preferences. This insight will help guide efforts to evolve and improve VR as an educational tool, as well as future research routes. Given the current uncertainty regarding how a post-pandemic world will operate, and the potential upside to distance learning for many disadvantaged students, it is key that we invest in effective distance learning systems.

I worked as a research assistant in the Virtual Human Interaction Lab for nine months, beginning in April 2020 and ending in December 2020. During this time, I helped manage a lab study examining children’s use of virtual reality as an educational tool at home during the COVID-19 pandemic. The study was mixed-methods and consisted of a larger sample survey, longitudinal surveys, and participant interviews for parents of children in homes with at least one working VR headset. This was a unique opportunity to examine the role VR played in children’s education and entertainment during the height of the pandemic lockdowns, and to gain insight into children’s use patterns. My main contributions included overseeing study logistics and managing participants, literature review, thematic data analysis, and a faulty data detection scheme, as well as many additional tasks as needed.

I was involved in oversight of logistics of the study. I managed three cohorts of longitudinal study participants totaling 170 people, organizing their survey responses and fielding occasional questions from participants, during May 2020 through July 2020 (see appendix A). I sent out multiple rounds of mass emails per week to remind participants to take their surveys on time over a period of over two months to the relevant cohort(s) to ensure high
survey response rates: an email the week before to remind cohort(s) that they would receive a survey the next week, an email at week’s beginning with the survey link, and a deadline reminder email to those who had not yet taken the survey asking them to complete it by the end of the day. Each cohort took the survey every two weeks. In addition, I built the questionnaires and survey logic in Qualtrics; contributed to survey dissemination efforts by finding the contact information for and emailing around 100 private schools; wrote and edited email templates; anonymized a dozen automatically generated interview transcripts and corrected errors; conducted a thorough literature review of educational VR; hand-counted and tracked every mention of approximately 170 VR apps in all of the survey responses (see appendix B); researched and entered app metadata into a document (see appendix C); recorded which surveys each participant responded to (see appendix A); and performed some limited data analysis to determine how many participants in each cohort responded to a certain number of surveys (see appendix A).

When we had collected the data we needed, I transitioned to assisting with qualitative data analysis. Together with my fellow research assistant, Carlyn Strang, I helped create a presentation outlining our proposal for a data coding scheme, which we gave to our fellow researchers. I contributed to qualitative analysis of the data (see appendix D). I also assisted in resolving coding disagreements between researchers and compiling coding efforts into a spreadsheet. While reviewing the collected data, I noticed that some survey responses were suspiciously similar—they contained the same words or phrases, mentioned the same VR apps, and were submitted within minutes of each other. Participants would have been incentivized to submit multiple responses under different email addresses due to the $30 Amazon gift card they were rewarded for completing the longitudinal surveys. I recognized the need for a faulty data detection scheme and created a set of rules to standardize elimination of repeated responses. I
then checked the survey responses one by one and flagged the faulty data. When I shared my detection scheme and the flagged survey responses with my fellow researchers, they agreed that the data should be removed from the study (see appendix E).

Aside from my contributions to the data analysis, I worked with Carlyn Strang to draft and revise the methods section of the paper and created figures as needed to illustrate the process (see appendix F). I generated the citations for the bibliography. While we had originally planned to split the study into a poster and a paper, both submissions were rejected at our first choice conference and journal. The project is now being reorganized into a single paper that we plan to submit to the journal *Presence*. I will be listed as a co-author on this paper.

Over the course of our study, we made several main findings. Firstly, children’s use of virtual reality increased significantly during the start of the COVID-19 lockdowns. However, as the lockdowns began to lift, the number of hours children spent in VR began to flatten, ostensibly due to the slow return to pre-pandemic “normal” VR use conditions. We applied uses & gratifications theory to our results and concluded that the five main gratifications children receive from VR use are “escape,” “socialize,” “exercise,” “learn,” and “travel.” If children did not have friends with access to a VR headset and/or social VR games or platforms, the gratification “socialize” also acted as an inhibitor since children would choose other methods of socializing outside of virtual reality. This finding points to the importance of reducing the cost barrier to VR to reach a critical mass of users—in the current moment, quality headsets cost between $300-$700. We found that children using VR could be categorized as “gamers” or “non-gamers” depending on the VR applications they gravitated towards. In examining childrens’ user profiles, boys spent significantly more time using VR than girls. The majority of our parent participants (nearly 70%) were male, which may be explained by our recruitment
method of soliciting participants through VR industry professionals given the well-known gender divide in the tech world (Maynard). In terms of the applications used, we found that only 6 of 169 were in use by over 10% of participating households, indicating a need for a centralized app database or sharing system. Our “visual and performing arts” category of applications accounted for the largest proportion of apps mentioned, followed by “biology,” “physical education,” and “history.”

There were several limitations to our study. Firstly, while conducting our interviews and surveys during the first months of the COVID-19 pandemic provided insight into use patterns of virtual reality during that time, we did not have a basis of comparison from before the pandemic or from later in its progression. Our recruitment methods favored parents who were experienced VR users who often owned multiple headsets. Furthermore, we relied entirely on self-reporting by parents on their children’s VR usage as we conducted this study remotely. While the study lays the groundwork for future research, we did not explore the effectiveness of educational applications.

In conclusion, virtual reality has great potential as an immersive distance learning system for children, to supplement their existing education and to act as a substitute for in-person learning should the need arise. As perhaps the only study specifically focused on virtual reality use during the early stages of the pandemic, our research was a one-time opportunity to examine the ways in which children used VR during the onset of a global disaster. Our finding that boys tended to use VR longer than girls paralleled the gender gap in the VR and tech industries. In applying the uses & gratifications framework to virtual reality, we discovered five main gratifications for children’s VR use, “escape,” “socialize,” “exercise,” “learn,” and “travel.” Many educational VR applications exist, but they are concentrated in the visual and performing
arts category. While households have found a few educational applications on their own, there is little overlap between apps used in each household due to the lack of a centralized guide to educational apps. Further studies should dive deeper into the viability of VR as a substitute for in-person learning; build on our research by testing the efficacy of specific VR learning programs for children; and provide a strategy for VR companies to pursue with the goal of further developing the field of educational VR.
Appendix A: Participant Management

Below is a selection of the longitudinal survey participant tracking sheet I created and used. The spreadsheet includes 178 rows of longitudinal survey participants. Participant emails and names have been redacted. A green “1” indicates that the survey was completed, and a red “0” indicates that the survey was not completed. I sent out all emails with survey links and all email reminders to each of the longitudinal survey participants. In the bottom image, the right three columns include calculations I performed for Cohort A, which I repeated for Cohorts B and C, which reflect the longitudinal survey completion rates for the cohort.
Appendix B: Data Management

Below are two screenshots of the longitudinal survey response spreadsheet I created and managed, with names and email addresses redacted. The spreadsheet consisted of 13 tabs—three cohorts with four rounds of responses each, plus one tab of responses submitted past our deadline. The pink highlighting indicates a questionable response flagged using my detection scheme. There were 407 responses in total, including those that were either late or suspicious.

<table>
<thead>
<tr>
<th>Recorded Date</th>
<th>Recipient Last Name</th>
<th>Recipient First Name</th>
<th>Virtual Reality For Education in Times of Global Crisis: Biweekly Update</th>
<th>Enter the email at which you received this survey:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020-05-18 8:20:07</td>
<td></td>
<td></td>
<td>I consent, begin the</td>
<td></td>
</tr>
<tr>
<td>2020-05-18 8:25:08</td>
<td></td>
<td></td>
<td>I consent, begin the</td>
<td></td>
</tr>
<tr>
<td>2020-05-18 8:32:11</td>
<td></td>
<td></td>
<td>I consent, begin the</td>
<td></td>
</tr>
<tr>
<td>2020-05-18 8:35:44</td>
<td></td>
<td></td>
<td>I consent, begin the</td>
<td></td>
</tr>
<tr>
<td>2020-05-18 8:50:43</td>
<td></td>
<td></td>
<td>I consent, begin the</td>
<td></td>
</tr>
<tr>
<td>2020-05-18 8:52:42</td>
<td></td>
<td></td>
<td>I consent, begin the</td>
<td></td>
</tr>
<tr>
<td>2020-05-18 9:12:08</td>
<td></td>
<td></td>
<td>I consent, begin the</td>
<td></td>
</tr>
</tbody>
</table>
Below is a selection from a spreadsheet I used to count the number of applications mentioned in our study and to locate the mention in either the interviews, the large sample survey (“Survey 1”), or the longitudinal surveys (“Survey 2”). I added 525 rows of apps to this spreadsheet.

<table>
<thead>
<tr>
<th>APP NAME</th>
<th>INTERVIEW(S)</th>
<th>SURVEY 1</th>
<th>SURVEY 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traveling While Black</td>
<td>7-8, 13, 20</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Tribeca Virtual Arcade @ Cannes VR</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>TribeXR</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Trover Saves the Universe</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Later, we realized we needed exact numbers of how many times participants mentioned VR apps. Below is a selection from a spreadsheet I used to do more detailed counting. I hand counted all mentions of every VR application in the longitudinal survey responses and in a few of the interview transcripts (my colleagues were responsible for counting in the rest of the transcripts). Below is a sample of the spreadsheet I created and used for the app counting. The “App Name” column includes every single mention of an app, and the “Final Apps Per Participant” column removes duplicate mentions. I compiled the “Final Apps Per Participant”
column contents into another tab, which I used to count app mention totals across all participants. The longitudinal survey app mentions consisted of 899 rows.
Appendix C: Collecting App Metadata

Below is an example of the information I collected for one VR application. In total, I completed approximately 70 pages’ worth of metadata collection for VR apps.

**The People’s House**

Developer: Felix and Paul Studios
- Producer: unknown

Release Date: May 1, 2017

Snapshot:

Short Description: The People’s House takes you on a historic visit to President Barack Obama and First Lady Michelle Obama’s White House. Through the transportive power of VR, the Obamas take you on an intimate journey inside the West Wing, Executive and Private Residences, reflecting on their time there, and recounting the building’s profound history since its creation over two centuries ago.

- CG Experience
- Genre: Politics, Educational, History

<table>
<thead>
<tr>
<th>Availability</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oculus</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Appendix D: Qualitative Analysis & Themes Coding

Together with my fellow research assistant, Carlyn Strang, I proposed coding themes for our interview transcripts through a presentation to our supervisors. Below is a representation of our overall theme organization, and a selection of slides I created. I was responsible for the “pandemic as competitor” section of the presentation.

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**Pandemic as Competitor**

The ways in which the pandemic constrains children's VR use.

- Shelter in Place
  - Social
  - Weather/Outdoor
  - Other
- Reopening (Social)
Shelter in Place

Definition: The ways in which the shelter in place measures of the pandemic constrain childrens’ VR use.

Subcategories: Social, Weather/Outdoor, Other

Shelter in Place: Social

Definition: Due to school closures, children cannot interact face to face or use VR with friends in person. As a result, they favor other technologies that allow for long distance socializing or decrease VR usage overall.

Example: “Anything where their friends are doing it, especially right now when they don’t have the physical social interaction, that is what they’re doing. So if more of their friends had a VR unit, they’d be playing... But because their friends are PC gaming and playing games on consoles like PS4 or Xbox, that’s where they’re spending their time because that is their primary source of social interaction right now.”
I also read through all of the longitudinal survey responses and interview transcripts, and wrote down 89 rows of preliminary observations and reactions that could potentially feed into coding themes. A sample screenshot is below.

<table>
<thead>
<tr>
<th>Quote</th>
<th>Location</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have to take the headset off of her she's never, &quot;I'm done.&quot;</td>
<td>Interview 4</td>
<td>Parental restriction on VR use time</td>
</tr>
<tr>
<td>I think she was in it for half an hour where she was literally creating instruments and then playing them and she was designing them and you know, things where she's able to manipulate things with her hands, she seems to have a greater affinity towards.</td>
<td>Interview 4</td>
<td>It just seems like the kids really thrive on the creative aspects of VR. Given how many times Till Brush is mentioned and how into creating things in VR the parents report them to be.</td>
</tr>
<tr>
<td>Generally, when I use it, I'm in the same room with her. which is super colorful.</td>
<td>Interview 5</td>
<td>VR as a group experience, whether with family or with friends</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A couple different ones have mentioned color or the animation being convincing as reasons why the children enjoy a certain game or VR more. More colorful and more realistic = better</td>
</tr>
</tbody>
</table>

I tested a coding scheme on 31 selections from interview transcripts. One of my rows of coding is below.
Most boys go to their father's every other week where they do not have VR access. My oldest has been selected to beta test a new PC game, so he has dominated the time on the PC for that. Neither boy has spent any time on the VR system in the past 2 weeks due to those reasons. They have spent a lot of time gaming though. I wish there were more educational options that were fun to them. It's difficult as a parent to limit their play times during the pandemic especially when that's how they get most social interaction with their friends. I would rather they have that interaction through gaming than restrict their time and thereby restrict further their interaction with friends. It's a tough line to walk.

<table>
<thead>
<tr>
<th>Categories (choose at least 1)</th>
<th>IF CATALYST (choose 0-2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalyst</td>
<td>Competitor</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IF SHELTER-IN-PLACE (choose 0-2)</th>
<th>IF REOPENING (choose 0-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social interaction</td>
<td>Weather/outdoor</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Appendix E: Fake Responses Detection Scheme

- **Responses that include almost the exact same sentences.**
- **Responses from the same participants submitted within a few minutes of each other across multiple rounds of the survey.**
- **Responses that recycle the same apps over and over.**
  - Some of these repeated apps are more obscure, like Imag-n-o-tron.
  - If you use command-F to search for a specific app that is repeated (Sites in VR, Anatomy 4D, Star Chart, Earth AR, Google Translate, or even NA, etc.), you can see that these repeated apps appear almost exclusively in the block of highlighted responses that were submitted within a few minutes, and not nearly as frequently in the other responses. It's as if they had a list of 15 apps they were recycling in different combinations of 4 for each response.
- **Responses characterized by strange and fragmented phrases, often recycled in different forms for the freewrite responses. The writing style is recognizable and repetitive.**
  - Examples of these kinds of strange responses:
    - “Yes, the child's performance has been better than before. It has found its habit and became a habit. This is not easy.”
    - “I am very benefited, the child's learning effect is very good, it learns like a toy.”
    - “Adapt hard.”
  - A “normal” and non-suspicious response is typically longer and looks like this:
    - “We recently went on vacation out of state and the use of VR has actually increased with us bringing the oculus quest with us. There was usage on the plane ride to watch a movie or two and they shared the headset with older family members. They all played a variety of games and apps including pistol whip, gun club VR, and Anne Frank house VR.”
  - At first I thought this might be a language issue since we have international participants, but the prevalence of it, together with all of these other factors, convinced me otherwise.
  - An example of a free-write repeat:
    - “When I first started using it, I was a bit curious. After using it for a long time, it was not very attractive to VR.”
    - Submitted four minutes later: “There was some curiosity when I started using it. As time went on, I was less interested in VR.”
- **Lots of "NA" and "none" as if they were rushing to submit as many responses as possible.**
- **Email addresses with lots of letters and numbers.**
- **Almost all of the suspect responses are in Cohort A.**
  - Only two of the suspicious respondents are in Cohort C. Their writing style & app names are the same as the large blocks of highlighted responses in Cohort A, and they submitted responses within a couple minutes of each other in all four of the longitudinal surveys.
Appendix F: Draft of the Methods Section, Co-Written with Carlyn Strang

This study employed mixed methods and consisted of three parts. In Part 1, participants filled out an initial survey. In Part 2 participants sign up for a series of longitudinal surveys which were administered over the course of 2 months. In Part 3, 20 semi-structured interviews were conducted online.

Participants did not receive compensation for completing Part 1 of the study. However, participants were notified that they would be compensated with a $30 Amazon gift card upon the timely completion of all four longitudinal surveys in Part 2. Those who did not take the longitudinal surveys but signed up specifically for Part 3, the video conference interview, did not receive compensation.

Figure XX: The division of this study into Parts 1, 2, and 3. In Part 1, participants took the first survey. Upon completing the survey, they signed up for Part 2, or ended their participation in the study. In Part 2, participants took a questionnaire every two weeks. Later in the study, Part 2 signups closed and were replaced with Part 3 signups. Some Part 2 participants were contacted and invited to join Part 3. Part 3 consisted of an online video conference interview with the researchers.

Description of the Procedure

Part 1

This study recruited parents or legal guardians of children (0 to 18 year old) whose household owned at least one VR headset. In order to recruit these participants, a large online dissemination effort took place. The research team contacted approximately 250 heads of private schools along with some local schools. The leaders of approximately 45 VR and/or EdTech companies along with researchers in the field of VR were invited to participate in the study and asked to extend the invitation to their network.
Information about this study was also distributed on social media platforms such as Twitter, 58 VR Facebook communities and 30 VR Reddit communities. The study was also disseminated through various newsletters and blog posts.

In Part 1 of the study, participants filled out a survey which consisted of questions regarding their perception of educational VR content, their children’s VR-use patterns, and their children’s favorite VR applications. This survey took approximately 10 minutes to complete and was available from May 4th until July 2nd. Participants did not receive compensation for completing Part 1 of the study.

From May 4th to May 27th, the survey’s closing message included information and a sign up form for Part 2. Following May 28th to July 2nd, participants could no longer sign up for Part 2 but were invited to leave their contact information for a potential interview with our research team.

Part 2

Part 2 participants agreed to fill in a total of four surveys; each survey was administered every two weeks over a two-month period. They received a $30 Amazon gift card as compensation. Participants were asked to fill in each survey within a two-day response timeframe. Participants that signed up for Part 2 in the first, second, or third week of Part 1 were divided into cohorts A, B, and C respectively; each cohort began taking the surveys during one of three consecutive weeks (Figure XX). Some Part 2 participants were also contacted via email and invited to join a 40-minute long interview through video conference.

Every two weeks, participants received a pre-notice email on Friday afternoon alerting them to the survey’s arrival the next Monday. After receiving the survey via an automated Qualtrics email on Monday at 5:00am PST, participants had until Wednesday at 11:59pm PST to respond. Participants who did not complete the survey by Wednesday at 5:00am PST were sent another email which reminded them to complete it before midnight that day. Cohort A began receiving surveys on May 18th, Cohort B began receiving surveys on May 25th, and Cohort C began receiving surveys on June 1st. All cohorts received surveys every other week based on their respective start date.

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<td><strong>PART 2</strong></td>
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<tr>
<td><strong>SIGNUP</strong></td>
<td>A</td>
<td>B</td>
<td>C</td>
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<tr>
<td><strong>SURVEY 1/4</strong></td>
<td>A</td>
<td>B</td>
<td>C</td>
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<tr>
<td><strong>SURVEY 2/4</strong></td>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>SURVEY 3/4</strong></td>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SURVEY 4/4</strong></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
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Figure XX: Schedule of the administration of Part 2 surveys. Participants were divided into cohorts according to the week they joined Part 2. Thus, Cohort A participants signed up during the week of 5/4, and took the Part 2 survey every other week beginning the week of 5/18; Cohort B participants signed up during the week of 5/11 and began the surveys the week of 5/25, and so on.

Each survey took approximately 8 minutes to complete and included a timed, 4-minute, free write section concerning how the family unit’s kid(s) had used VR for the past two weeks. The other questions determined whether the kids’ use of educational VR applications had changed since the previous survey. Specifically, they were asked whether the kid(s) had stopped using old applications, started using new applications, or whether anything else had changed. All four surveys contained the same questions, with the exception of an additional set of cybersickness questions included in the fourth survey.

After survey 1 out of 4 was closed, the researchers sent an email to participants who did not complete it, notifying them that they could still receive the $30 Amazon gift card compensation provided that they complete part 2/4, 3/4, and 4/4 on time.

Part 3
Participants who signed up for interviews were contacted by the researchers via email notifying them that they had been selected for an optional video interview. Most participants who consistently participated in Part 2 received interview requests; gender equality was maintained in selecting interviewees until the number of men exceeded the number of women. Upon their consent, virtual Zoom meetings were scheduled.

All interviews lasted between 20 and 55 minutes. During the interviews, researchers first inquired about whether the family’s use of VR applications and time spent in VR had changed as a result of school closures. The researchers then aimed to gain an understanding of the role that educational VR played in each family by asking participants about their use of and attitude towards the available educational VR applications. Finally, researchers attempted to understand parents’ levels of comfort with VR technology through asking about their perception of its drawbacks, the appropriate age for kids to begin using VR, and child-parent dynamics while using VR.

Once all interviews were complete, transcripts were created using transcription software, corrected by researchers, and anonymized. Audio recordings were destroyed at the conclusion of the study.
Works Cited
