

Understanding Adult Stakeholder Perspectives on the Ethics of Extended Reality Technologies with a Focus on Young Children and Children in Rural Areas

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ABSTRACT

As part of a larger initiative with the goal of developing ethical guidelines for conducting extended reality (XR) research with children, this paper presents the qualitative analysis of 24 sessions conducted with parents, teachers, medical professionals, and other adult stakeholders with a focus on young children and rural areas. The sessions included discussions of fears and hopes with respect to technologies and children based on prior literature, in-depth consideration of a broad range of potential use scenarios, explanations of how XR headsets work, and use of commercially available headsets. An inductive analysis of notes from sessions resulted in a data structure with the following aggregate dimensions: 1.) privacy and safety; 2.) managing content; 3.) developmental, physical, and behavioral impacts; 4.) broad concerns about emerging technologies; 5.) balancing XR and reality; and 6.) contextual considerations. We include details on each of these aggregate dimensions as well as a grounded model derived from them, providing examples of how these dimensions interact with each other to influence stakeholder perspectives on the ethics of specific uses of XR.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); • **Social and professional topics** → User characteristics; Age; Children.

KEYWORDS

young children, preschool children, extended reality, ethics

ACM Reference Format:

Juan Pablo Hourcade, Summer Schmuecker, Delaney Norris, and Flannery Hope Currin. 2024. Understanding Adult Stakeholder Perspectives on the Ethics of Extended Reality Technologies with a Focus on Young Children and Children in Rural Areas. In *Interaction Design and Children (IDC '24)*, June 17–20, 2024, Delft, Netherlands. ACM, New York, NY, USA, 14 pages. <https://doi.org/10.1145/3628516.3655811>



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IDC '24, June 17–20, 2024, Delft, Netherlands

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ACM ISBN 979-8-4007-0442-0/24/06

<https://doi.org/10.1145/3628516.3655811>

1 INTRODUCTION

Extended reality (XR) technologies, which for the context of this paper we refer to as virtual and augmented reality technologies delivered through headsets, are an emerging technology when it comes to young children. While commercial devices have been popular with adults [13], they are not designed for young children's anatomy (the average interpupillary distance of a 5-year-old is 51mm, too narrow for commercially-available headsets) [31, 59], and manufacturers of the most popular models recommend use by those 10-13 and older [69]. However, the quick pace of development for this type of technology, together with its associated opportunities, make it possible that it could eventually become a non-trivial player in young children's technology ecosystem.

We believe that this is an appropriate time to develop ethical guidelines for research into XR technologies for children given that we could have an impact on practical applications of these devices. This is something that the child-computer interaction community was unable to do with smartphones and tablets, for example, and the resulting outcomes have not necessarily been the most beneficial for many children, with uncreative, socially isolating, and privacy-defying uses prevailing [79, 83]. We should at least try to have an impact with current emerging technologies.

In approaching ethics, we are referring to moral principles, arising from societal norms and virtues, that in the case of emerging technologies, affect both the design and use of the technologies. Given their nature, ethics are closely tied to personal and sociocultural values [94] and to contextual aspects [100] that may affect the appropriateness of a use. Hence, we believe it is important that these ethical discussions include the perspectives of stakeholders, rather than just those of experts or industry leaders [81]. We also believe that the effects of emerging technologies on young children need to be considered, something that is often missing from societal discussions on the impact of emerging technologies, which tend to focus on adults and teenagers, as can be seen, for example, in current discourse about generative artificial intelligence [17, 19, 39, 41, 48, 58, 61, 63, 64, 67, 86, 95, 98].

To address the lack of stakeholder-centered ethical considerations of XR technology for children, a group of child-computer interaction researchers has formed a consortium to investigate the topic, with the goal of developing ethical guidelines for XR research with children. Each site in the consortium is using participatory

methods to engage with different groups of stakeholders. The work presented in this paper is a first step in this direction at one of the consortium sites, engaging with adult stakeholders (e.g., parents, teachers, health professionals) and focusing on young children (ages 2-5) and rural populations. More specifically, we present a qualitative analysis of 24 sessions in which we engaged a total of 23 adult stakeholders. The results point at many similarities with existing discourses on the ethics of other technologies for children, but also some ethical concerns specific to XR technologies, and connections with the ethics of another emerging technology: generative artificial intelligence.

2 RELATED WORK

Documents, such as the Declaration of Helsinki [14] and the Belmont report [20], provide basic direction on ethics that can guide considerations for emerging technologies. They call for beneficence, non-maleficence, and the upholding of norms and virtues, such as autonomy and justice. Professional organizations, such as the ACM and IEEE have codes of ethics that delve into computing [1, 53]. When it comes to children's technologies, there have been contributions both on ethics, but also on concerns about emerging uses of technology by children, from the likes of non-profit organizations [56, 106], professional associations [49], academics [97], government policies [92], and international organization guidelines [35].

Missing from these conversations, for the most part, are the stakeholders (including children aged 3-12) affected by these technologies, and the child-computer interaction community, which we believe is well-placed to give them a voice, and that in spite of amply discussing ethics [4, 6, 7, 36, 37, 51, 99], has not played a role in societal discussions. The lack of stakeholder involvement is a well-known, yet recurring problem, whereas most of the discussions on ethics come from experts and industry leaders [81]. Top-down approaches, while useful, do not often consider the daily realities and values of the broader population that may use or is affected by technologies.

Participatory approaches to ethical concerns about children's technologies can complement these existing top-down approaches. As such, they are more likely to address stakeholder's concerns and their realities. In addition, they can consider the norms and virtues valued by stakeholders with respect to children, which may be different from those held by industry leaders and academics, and different from those that matter with respect to adults. For example, autonomy, is typically applied differently to children and adults (e.g., we expect parental consent for research activities in addition to children's consent) and industry may have a different view from the public too (e.g., with respect to decision-making about private information). The other positive aspect of participatory approaches is that they can be combined with other approaches to consider the ethics of emerging technologies [21, 81]. Brey argues for such an approach, making the case that methods to consider the ethics of emerging technologies can be combined with participatory approaches [21].

Participatory methods that aim to raise the voices of stakeholders, including children, could fill a gap in current public conversations about technology and children. Not only would these methods

bring forth new perspectives, but they may also enable and facilitate better communication with stakeholders by more authentically representing their values, priorities, and vocabulary. In addition, they would enable the child-computer interaction community to better contribute to the public conversation on the ethics of emerging technologies and children. Not surprisingly, others have made calls for similar approaches outside [26] and inside the human-computer interaction community [72]. However, most past experiences have been about the ethics of or values associated with what is being designed (i.e., taking into account values in the design process) [38] rather than the ethics of products made by third parties and their uses. Efforts closer to ours include UNICEF's *Responsible Innovation in Technology for Children* report [82]. One difference between that project and ours is that we are focusing, in depth, on a specific technology rather than broad goals about well-being related to digital experiences. A further difference with the research presented in this paper is our focus on young children, who were not included in UNICEF's report [82].

3 RESEARCH QUESTION

In the work we present in this paper, we sought to answer the following question with a focus on young children, and children living in rural areas or small towns in the United States: What are the ethical perspectives of adult stakeholders with respect to XR technologies and children? The rationale for including rural areas and small towns is that child-computer interaction research is rarely conducted in these locations and we thought they could provide novel perspectives.

4 RESEARCH SETUP

4.1 Setting and Participants

The study was conducted at two sites in the United States. One site was a community center in a small town of about 700 people. The closest larger city (population around 60,000) to this town is located about 60 km away. The other was a conference room at our university, which is in a metropolitan area of about 150,000 people and is surrounded by rural areas.

We recruited adult participants through a combination of flyers and mass emails. Both directed them to an online survey to determine their eligibility to participate. We had different eligibility criteria based on whether participants lived or worked in rural areas or small towns (population under 10,000). If they lived in a rural area or small town, they had to be the parents of 2-12-year-old children, or their job had to involve working with 2-12-year-old children (e.g., as teachers, doctors, therapists). If they did not meet the criteria for living in a rural area or small town, then they had to be the parents of 2-5-year-old children, or their job had to involve working with 2-5-year-old children. We invited eligible individuals to sessions held at one of the two study sites. Participants received checks for \$50 for each session in which they participated.

A total of 23 adults participated in study sessions. 18 were female, 4 male, and 1 preferred not to specify a gender. Six participants were eligible solely because of their profession (including teachers, a pediatrician, a nurse, and a therapist), 2 qualified both as parents and professionals, and 15 qualified as parents only (9 qualified as parents of 2-5-year-old children). Eleven lived or worked in rural

Table 1: Participant characteristics and number of sessions in which they participated.

Participant ID	Gender	Small Town or Rural	Parent	Professional	Number of Sessions
1	Male		X		12
2	Male	X	X		9
3	Female		X		5
4	Female		X		1
5	Female	X	X		1
6	Not specified		X		7
7	Female	X		X	5
8	Female		X		5
9	Female		X		3
10	Female	X		X	7
11	Female		X	X	1
12	Female		X		11
13	Female	X		X	9
14	Female			X	1
15	Female		X		9
16	Male			X	9
17	Female			X	7
18	Female	X	X		1
19	Female	X	X		2
20	Female	X	X		2
21	Female	X	X		1
22	Female	X	X	X	2
23	Male	X	X		2

areas or small towns. Table 1 lists participants, their characteristics, and the number of sessions in which they participated. We aimed to have no more than 10 participants per session. Variations in the number of participants per session were due to participant availability for a given session date and time. Our protocol was reviewed and approved by our university’s Institutional Review Board.

4.2 Materials and Procedure

We conducted a total of 24 sessions, each lasting about one hour. During each session, we conducted one of five types of activities: filling out and discussing items on a questionnaire on parental attitudes toward children’s technologies, discussing characteristics of extended reality technologies, reacting to and discussing scenarios of use, experiencing extended reality technologies, and validating a preliminary summary of notes taken during sessions. To preserve participant confidentiality, two researchers took extensive notes during each session, rather than recording them. Table 2 provides details on the location of each session, what activity was conducted, and which participants listed on Table 1 participated.

Below, we provide more detail on each type of activity conducted during sessions.

4.2.1 Questionnaire to Gauge Adult Participants’ Opinions on their Hopes and Fears with Respect to Children’s use of Digital Technologies. The questionnaire includes 62 items derived from prior literature on risks and benefits of children’s technologies and does not

focus on a specific type of technology. Topics include technology’s impact on children’s relationship to the physical or “real” world, family dynamics, social-emotional well-being, and education, creativity, and expression. It is delivered through a q-sort activity, which enables respondents to sort statements based on their level of agreement and disagreement [101]. These activities can be used to identify groups of respondents who have similar views on technologies and children [75, 101]. We used the questionnaire for the purpose of broadening the perspective of stakeholders as to the risks and benefits of technologies for children and help us understand the perspectives with which stakeholders arrive at sessions. Note that the questionnaire is not written to push specific values or perspectives, but rather to expose stakeholders to a range of potential risks and benefits.

Prior to using the questionnaire in this research, we had conducted a separate research activity with 49 parents where they completed the questionnaire. That prior activity enabled us to produce three personas based on the clustering of responses enabled by this approach. After parents completed the questionnaire, we also exposed them to the personas and asked them if they identified with one of them, multiple personas, or none, and whether they knew other people not represented by the personas. These discussions helped us better understand the range of perspectives on technologies for children among participants, as well as have a sense of any perspectives we may be missing.

We include the questionnaire and the personas used in the supplementary documents.

Table 2: List of sessions in chronological order, the location where they were held, the activity conducted, and the participants from Table 1 who participated in them.

Session ID	Location	Activity	Participants
2023-03-04	Small town	Experiencing extended reality technologies	18, 19, 20, 21, 22, 23
2023-04-01	Small town	Filling out and discussing questionnaire	19, 20, 22, 23
2023-06-06	University	Filling out and discussing questionnaire	1, 4, 10, 12
2023-06-09&10	University	Filling out and discussing questionnaire	7, 9, 13
2023-06-13	University	Reacting to and discussing scenarios of use	10, 12
2023-06-17	University	Reacting to and discussing scenarios of use	11, 13
2023-07-01	University	Reacting to and discussing scenarios of use	1, 7, 13
2023-07-08	University	Reacting to and discussing scenarios of use	7, 12, 13, 15
2023-07-11	University	Discussing personas from questionnaire activity	2, 10, 14, 15
2023-07-15	University	Reacting to and discussing scenarios of use	3, 5, 6, 12, 15
2023-07-18	University	Reacting to and discussing scenarios of use; experiencing extended reality technologies	2, 6, 8, 10, 12, 15
2023-07-22	University	Reacting to and discussing scenarios of use	1, 3, 7, 8, 13
2023-07-25	University	Discussing characteristics; experiencing extended reality technologies	1, 6, 8, 10, 12, 13
2023-07-29	University	Filling out and discussing questionnaire; Discussing personas from questionnaire	1, 2, 7, 13, 16
2023-08-01	University	Validating a preliminary summary of notes	1, 2, 3, 10, 12
2023-08-05	University	Validating a preliminary summary of notes	1, 13, 16, 17
2023-08-08	University	Experiencing extended reality technologies	1, 3, 6, 15, 16, 17
2023-08-12	University	Reacting to and discussing scenarios of use	1, 2, 3, 6, 9, 13, 15, 16, 17
2023-08-15	University	Experiencing extended reality technologies; discussing characteristics	2, 12, 15, 16, 17
2023-09-12	University	Reacting to and discussing scenarios of use (AI)	1, 2, 3, 6, 8, 12, 13, 15, 16, 17
2023-09-23	University	Reacting to and discussing scenarios of use (AI)	1, 2, 12, 15, 16, 17
2023-09-26	University	Experiencing examples of artificial intelligence technologies; reacting to and discussing scenarios of use (AI)	6, 8, 10, 12, 15, 16, 17

4.2.2 Characteristics of Extended Reality Technologies. Our second set of activities covered the characteristics of extended reality technologies. In these sessions, we explained to participants the data collection necessary for current headsets, as well as those for soon-to-arrive headsets, such as Apple's Vision Pro [9]. These characteristics include eye-tracking, creating a three-dimensional map of the room where the device is used, body tracking, face-scanning, and reproducing a virtual version of a scanned face. The sessions were intended to provide participants with a better understanding of extended reality technologies while enabling a discussion of issues with ethical implications, such as privacy concerns. To obtain feedback from participants, we explained a concept, enabled participants to ask any questions, and then got their reactions (e.g., concern about technologies mapping children's bedrooms and what would happen to that data).

4.2.3 Scenarios of Use. We obtained the greatest amount of feedback from the discussion of scenarios of use. To identify scenarios of use, we surveyed the literature on research projects using extended reality with children. In addition, we searched online for commercial extended reality apps or products geared at children, while also considering possible uses of apps designed for adults. We developed a total of 30 scenarios, with multiple variations under

most scenarios, which we include in the supplementary documents. The broad areas for the scenarios were: education and training [2, 10, 24, 27, 40, 45, 46, 52, 52, 54, 55, 62, 66, 68, 90, 96], culture and entertainment [22, 25, 57, 71, 78, 85, 89, 91, 102–104], social interaction [15, 50, 87, 105], and health, wellness, and accessibility [3, 11, 23, 28–30, 43, 60, 65, 73, 74, 76, 84, 88, 93]. While we do not consider the list of scenarios to be comprehensive, we believe it provides reasonable coverage for existing and likely future use scenarios. For each scenario of use, we presented it, and asked participants for their reactions (e.g., whether they thought the specific scenario was acceptable or concerning and why). As they reacted to scenarios, we also asked them to consider situational aspects including where and with whom children are using the technology, and the ability of responsible adults to monitor it.

4.2.4 Experiencing Extended Reality. For these sessions, participants used a variety of apps on two headsets: a Meta Quest Pro [80] and a Microsoft HoloLens [70]. The Meta Quest Pro was used to provide virtual reality experiences and had a wide range of apps available for participants to try, including ForeVR Cornhole [34], Beat Saber [18], Archery Training [12], and A Painter [8]. With the Microsoft HoloLens, participants experienced augmented reality first through the Tips app to learn hand gestures, then through the

3D Viewer app in which they made use of the Holograms and 3D Library tabs, which enabled them to place, modify, and animate virtual objects in the room where participants used the system. As participants used the headsets, we asked them to think aloud. We had four of each of these devices, so multiple participants could try them out simultaneously. After all participants used a specific system, we had a discussion on likes, dislikes, and things they would like to change (e.g., difficulty navigating 3D spaces, enjoyment in playing games).

4.2.5 Validating Preliminary Summary of Notes. After completing most of the sessions, we went through our notes and quickly organized and summarized them. We shared these initial summaries with participants to validate that we had not missed any major topics in this organized list. These sessions served the purpose of ensuring that there were no key insights we missed in our notes, and to give participants one last opportunity to provide feedback and give us their opinion.

4.3 Data Collection and Analysis

To analyze data from sessions, we used inductive coding methods [44]. To do so, using a tool called Lucidchart [77], two researchers independently created virtual sticky notes based on the notes taken by researchers during sessions, as sessions were completed. Each sticky note referred to a specific session and noted the coder's initials, followed by the concept brought up by a participant. In total, this process produced 1,025 such concepts noted in virtual sticky notes.

The same two researchers worked collaboratively, in consultation with a third researcher, to cluster the virtual sticky notes based on similarity to identify a more manageable number of categories (e.g., Gioia et al. mention 25-30 as an example [44]), giving them a descriptor. We followed this activity with what Gioia et al. refer to as a 2nd-order analysis, developing themes from the clustered categories [44]. From these themes we identified aggregate dimensions [44]. The use of Lucidchart enabled us to automatically produce what Gioia et al. refer to as a "data structure", a visual aid that displays a hierarchy, from 1st order terms, to 2nd order themes, to aggregate dimensions [44].

The next step involved moving from the data structure to an inductive model grounded in the data [44]. The key to this model was identifying the relationships between the themes and dimensions previously found [44].

5 RESULTS

We identified 6 aggregate dimensions in our data structure and organize the results based on these dimensions, under which we discuss second-order themes and include the number of observations per theme to give readers a sense of the amount of attention each theme received during sessions. After presenting each dimension, we discuss the grounded model in Section 5.7.

5.1 Privacy and Safety

Privacy and safety is an aggregate dimension we expected and one that is relevant to other technologies children are using and has been part of the discussion on children's technologies in the past

[5, 32, 79]. The aggregate dimension consists of two second-order themes: privacy and data security, and safety and security concerns.

In terms of privacy and data security (75 observations), stakeholders shared concern about the collection and storage of sensitive data that goes beyond the data collected through more commonly used devices, such as smartphones. For example, stakeholders were concerned about the sensitivity of devices making 3-dimensional maps of rooms where they are used (e.g., children's bedrooms), creating models of children's faces, tracking their expressions and body movements to the degree they can be reproduced and identified (e.g., identify signature movement style for a particular user), as well as eye-tracking information. While stakeholders understood that the use of this sensitive data was necessary for the functionality of many features in current and future XR devices, they expressed a strong preference for this data to be kept on the devices, if at all possible, and to be erased when no longer necessary for functionality. Stakeholders were very concerned about what could be possible if such sensitive data were to be used maliciously. At the same time, they expected full transparency on how and why companies (app and device companies) collect data and how they use it. This expectation was combined with a desire for more control over data collection that includes legal guarantees.

Safety and security concerns (47 observations) were related to data collection. Given the extensive and detailed data potentially collected, stakeholders were concerned about situations where models of children (e.g., their faces and facial expressions) could be used without their and their parents' consent. A related concern was that these accurate models of people could be used such that it would be difficult for children to know who or what they were actually interacting with through an XR device. This concern was compounded by a sense that children could be more easily tricked into giving out sensitive information or convinced to behave a certain way. The sensitivity of the data required by some features of XR devices brought up concerns about the long-term safety of data gathered through them. Given these concerns, stakeholders expect XR devices to ascertain the identity and authenticity of interlocutors and abide by the strictest security standards to secure sensitive data required for the devices to function.

5.2 Managing Content

Managing content is another aggregate dimension we expected that has topics in common with salient concerns about media consumption and social media interactions that are already present in children's current use of electronic devices [16, 42]. The second-order themes making up this aggregate dimension are: parental monitoring and controls, social media content and concerns, and children bypassing controls.

Among stakeholders, parents were particularly adamant about their interest in parental monitoring and controls (75 observations), although they mention knowing other parents with much more laissez-faire attitudes. At the same time, even the parents who had a strong interest in parental controls (most parents had young children) acknowledged an expectation of increased responsibility and decreased controls as children grow older. In terms of the types of controls parents sought, these included the ability to set limits on screentime, restrict which apps children could use, monitor

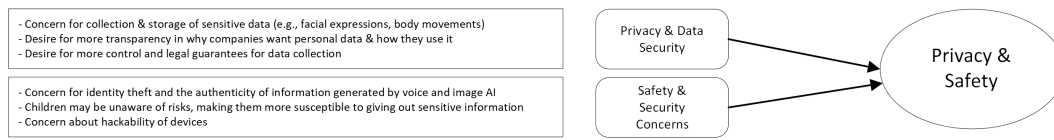


Figure 1: From left to right, descriptors and second-order themes for the privacy and safety aggregate dimension.

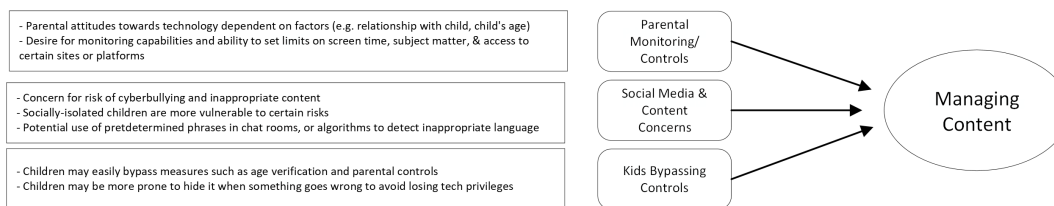


Figure 2: From left to right, descriptors and second-order themes for the managing content aggregate dimension.

for subject matters in terms of content, and provide access only to specific platforms and content. What was different about XR when compared to other technologies was the default inability to know what a child is experiencing in a headset, in contrast to parents having a greater opportunity to get a sense of what children experience when playing video games on a television or even using a smartphone. While current devices provide options to monitor what children are doing, stakeholders thought these options should be available by default and easy to access.

With regard to social media content and concerns (53 observations), stakeholders expressed worries about cyberbullying and how it could be amplified by XR experiences (e.g., it may feel more like in-person bullying), together with the potentially worse impact of inappropriate content for the same reasons (i.e., it may feel more realistic). There was a sense from stakeholders that socially isolated children could be more vulnerable to these risks. To avoid problematic encounters in social environments available through XR devices, stakeholders thought spaces for younger children could keep interactions to predetermined phrases and behaviors to avoid information disclosure, bullying, and other concerns. For older children, participants were open to the automatic detection of problematic communications and interactions but were concerned about how well such detection would work.

Related to the two other themes under this aggregate dimension, stakeholders were concerned that older children would find ways to bypass parental controls and other restrictions on content and social media interactions (13 observations). They also thought some children may be more prone to hide negative experiences to avoid losing the ability to use technology. Educational resources for parents and children could help in this regard.

5.3 Balancing XR and Reality

The aggregate dimension of balancing XR and reality is arguably, for obvious reasons, the most unique to XR technologies. It consists of the following second-order themes: preference for reality/human components, social development/interaction concerns, immersion

and distinguishing virtual reality from reality, and technology as a supplement, not a replacement.

The first theme expressed a consistent preference by stakeholders for reality and face-to-face human contact whenever reasonably possible (94 observations). For example, stakeholders mentioned a preference for going to a nearby friend's house or the playground over conducting similar activities on XR headsets. Within this theme stakeholders also brought up concerns about virtual social and physical interactions replacing face-to-face interactions and experiences in physical environments. Some stakeholders, in particular those providing services to children, also expressed skepticism that simulations of situations (e.g., walking to a particular location) would increase safety, as they could provide children a false sense of safety when going through the same situation in real life.

The second theme focused on social development (63 observations). Concepts within this theme included concerns about social isolation that could even go beyond that of mobile devices, with their associated impact on social development. The reason is that when using smartphones or tablets, children can still be somewhat aware of what is happening around them, something that may not always be possible when wearing a headset, unless it is in augmented reality mode. Some stakeholders also did not believe that XR technologies could replicate all the subtleties of real-world social interactions.

The third theme was concerned with the high level of immersion that can occur when using XR systems (39 observations). Stakeholders raised the issue of authenticity again, with concerns over whether young children, in particular, would be able to distinguish what is real and what is not. Stakeholders also brought up concerns about addiction due to immersion that could exacerbate social isolation issues. Finally, they had concerns that the level of immersion in experiences such as violent video games could feel much more real to the point of potentially traumatizing children.

A final theme under this aggregate dimension was related to the acceptability of virtual alternatives to real world activities (15 observations). Stakeholders found virtual alternatives acceptable if they were not the default and could be used in situations that

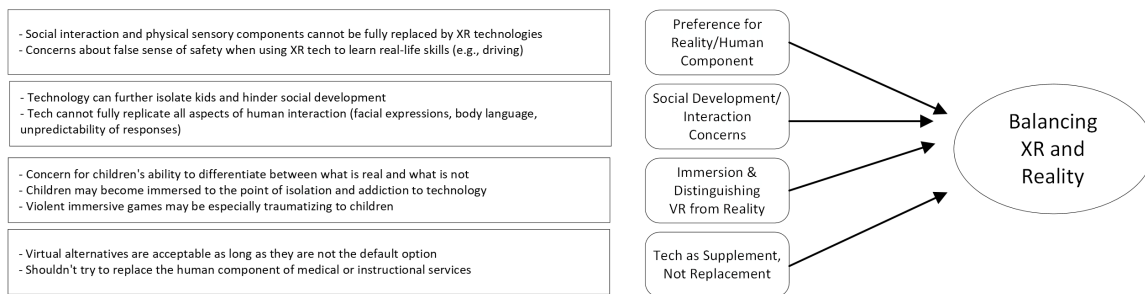


Figure 3: From left to right, descriptors and second-order themes for the balancing XR and reality aggregate dimension.

merit their use. For example, visiting a friend's house should be the default for a playdate, but virtual play could be an alternative if there is a storm and it is not possible to play in person. Similarly, if a museum is locally available, stakeholders preferred that children visit the museum in person, but were supportive of children visiting museums in other locations virtually. They also discussed that while virtual alternatives to medical or instructional services could sometimes make sense, that these should not replace real world interactions with medical professionals or teachers, but rather provide access in situations when it is not possible to meet in person. Stakeholders were thinking of children in rural areas in this case, whereas seeing a health professional sometimes requires a full day off from school (and off work for parents), and virtual options could lower burdens and increase access. At the same time, professionals who work with children thought that these options should always be supervised by professionals with in-person visits at appropriate times, to ensure that those receiving care through virtual means get the same quality care that children in areas with greater access to services receive.

5.4 Developmental, Physical, and Behavioral Impacts

The aggregate dimension of developmental, physical, and behavioral impacts shares a few common concerns with well-established children's technologies [5], together with some peculiarities related to XR. The two second-order themes contributing to this aggregate dimension are physical side effects and concerns, and technology addiction and behavioral concerns.

In terms of physical side effects and concerns (34 observations), stakeholders had very specific concerns about XR technologies that are not necessarily shared with others. Most of these were mentioned after sessions where participants tried out XR headsets. These concerns included motion sickness, headaches, eye-fatigue, and long-term effects on vision. The other concern expressed was related to viral videos most stakeholders had seen where users of XR headsets run into furniture, walls, and other people due to losing awareness of the surrounding environment.

Concerns about technology addiction and behavior (41 observations) involved stakeholders thinking about the unique experiences that XR devices could deliver leading to addiction and attempts for controlling this addiction resulting in family disputes. There were also associated concerns that these experiences could isolate

children from the real world around them, including family, by providing alternatives that may be more interesting or desirable.

5.5 Broad Concerns About Emerging Technologies

The aggregate dimension on broad concerns about emerging technologies addresses worries mainly related to unknowns about XR and related technologies. The second-order themes contributing to this aggregate dimension include the rapid pace of development of these technologies, the potential for overdependence and uncertainty about proper uses, as well as concerns specifically related to the emerging nature of XR and how it intersects with generative artificial intelligence.

The first of the second-order themes addresses the rapid pace of change of XR and related technologies (16 observations). Within this theme, stakeholders brought up concerns of market motivations leading companies to try to be the first out with a product, without taking proper time to consider potentially negative consequences. On a related note, participants worried about research on the benefits and harms of XR technologies not keeping up with changes, leaving parents without proper guidance on how to best use these systems. Stakeholders thought research was necessary and that it should be handled such that new uses are slowly rolled out rather than being made publicly available (e.g., similar to clinical trials). Even when research has been conducted, stakeholders were concerned about the amount of energy necessary to keep up with all the information about new devices and children.

Fears of overdependence on technology were also expressed by stakeholders (40 observations). These involved worries about children delegating not only work, but potentially even interactions with others to smart systems that could guide them or take over on their behalf (e.g., augmented reality telling children what to do, or children having a virtual version of themselves interact with others). Similarly, participants expressed concern about reliance on perceiving the world through systems that may not always be accurate (e.g., through content generated by generative artificial intelligence). Stakeholders also predicted that higher-income families would be more likely to reap benefits from the use of XR, with lower-income families unable to access services of similar quality.

In terms of concerns related to XR devices (91 observations), these mainly developed after stakeholders used devices. Their sense is that current devices are not ready for young children with the

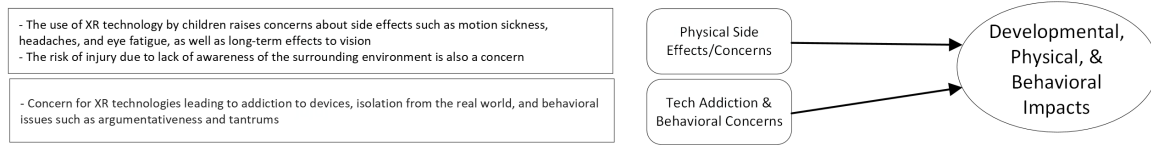


Figure 4: From left to right, descriptors and second-order themes for the developmental, physical, and behavioral impacts aggregate dimension.

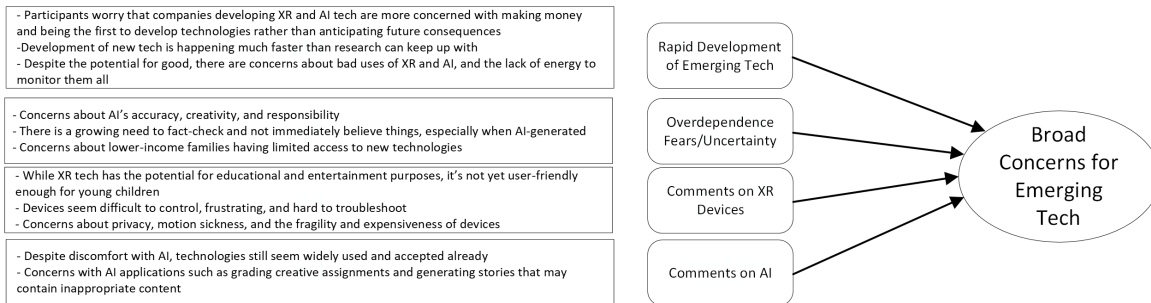


Figure 5: From left to right, descriptors and second-order themes for the broad concerns for emerging technology aggregate dimension.

question of when they will be still open. Specific issues they mentioned included broad usability concerns, but also concerns about privacy, motion sickness, and fragility. While there was a general sense that there are likely to be many positive uses, it was unclear to participants when devices will be ready to deliver these.

There were also discussions on the emergence of artificial intelligence technologies and how these may interact with XR technologies (40 observations). There was a sense that despite unease, these technologies are already being widely adopted and accepted. Some concerns brought up included automated grading of creative work that may be accomplished through XR devices (although some participants liked the idea of reducing bias in grading). There was also concern about artificial intelligence systems generating inappropriate content delivered through XR devices. Potential positives included using generative artificial intelligence to generate educational content to be delivered through XR devices that is customized to children's interests and daily realities.

5.6 Contextual Considerations

The aggregate dimension of contextual considerations is perhaps the most important as it was a key determinant for stakeholders' assessment of whether they found a specific use of XR to be ethical. The themes contributing to this aggregate dimension include context dependent use, affordability and access, use in hospitals, children's age and developmental stage, and sets of positive uses.

An important and not so surprising finding of the sessions was that the acceptability of many uses of XR has to do with context (119 observations). For example, the setting where the use occurs, who is present, the people with whom children interact, and the purpose of use all had an impact on acceptability. To make the most of out of contextual uses of technology, stakeholders also thought it important that professionals from fields relevant to the context

(e.g., education, health) participate in the design of technologies for use within that context.

A related and perhaps even more important finding had to do with affordability and access (23 observations). One specific consideration that stood out was the reasonable availability or access to similar activities in the real world, echoing findings from other themes as well. If these were available in the given context, then stakeholders preferred real world activities and thought XR experiences should be discouraged. However, if children were in a context that made similar real-world activities not accessible, then participants were more likely to favor XR experiences. Stakeholders were also positive on potential uses of XR to expand access to educational and medical resources in rural and low-income areas, but this hope was combined with a concern about affordability.

Since we had a few stakeholders that worked in a large hospital or otherwise regularly interacted with medical professionals, we had several comments on the use of XR devices in hospitals (19 observations). In fact, some uses of XR were considered positive only when children are hospitalized because they cannot otherwise access the outside world. These included virtually attending school, having virtual playdates, distracting children, and so forth. In this setting, what could be seen as isolating in other contexts, was perceived as enabling children to connect with others and with relevant activities in their lives.

With respect to age and developmental stages (39 observations), stakeholders thought that age recommendations should be based on research backing appropriateness for a particular age rather than an absence of negative information. When using current systems, they thought they were only appropriate for teenagers and up, consistent with current recommendations.

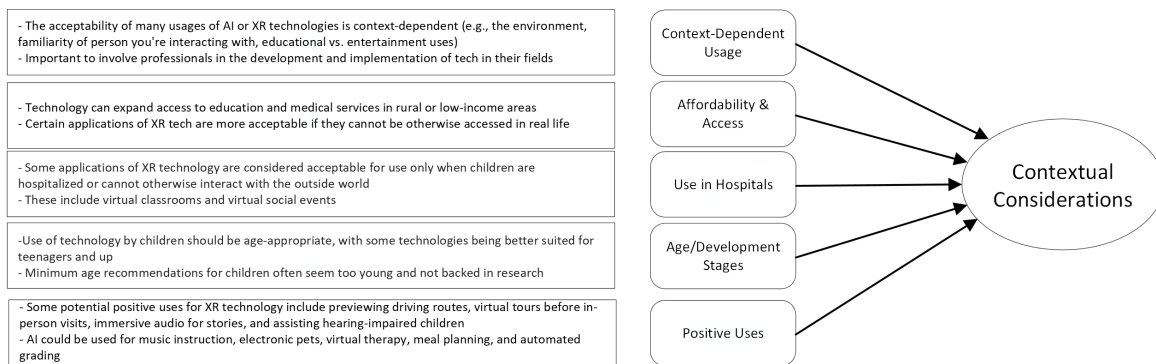


Figure 6: From left to right, descriptors and second-order themes for the contextual considerations aggregate dimension.

When discussing scenarios, stakeholders liked many of the ideas that have been studied and proposed through research (89 observations). In general, uses involving education, health, accessibility, and non-intrusive enhancements to existing activities received the best reception.

5.7 Grounded Model

Based on the aggregate dimensions, the research team developed a grounded model, displayed in Figure 7. The model has as an input the XR device being used and the specific scenario of use, including context. The output consists of the ethical considerations. In considering the relationships between aggregate dimensions that produce the output from the input we first organized the dimensions into four groups. Then we realized that first, each of these groups could be used to render a use unacceptable, and second, each group interacts with all the others.

The first group, which we refer to as data considerations, consists of the aggregate dimensions of privacy and safety, and managing content. An example of how this group could be used to render a use of XR unethical is relatively simple: some kinds of content would not be acceptable under any circumstance. At the same time, to render a use acceptable, this group interacts with the other three. For example, some forms of content may be more acceptable if they are not reasonably available in the real world (interaction with availability of real-world alternatives). Likewise, the appropriateness of content will depend on children's age and development. If the content is provided through a new type of experience, stakeholders will also want to ensure they understand its consequences, an interaction with broad concerns about emerging technologies.

The second group, availability of real-world alternatives, consists of the aggregate dimensions of balancing XR and reality and contextual considerations. Within this group, there are cases where stakeholders would find uses of XR to be inappropriate, such as in certain contexts (e.g., when children should pay attention to something other than the XR system), or when a richer real-world alternative is easily available. This group interacts with all the others. For example, some contexts, such as hospitalization, may make some uses, such as having playdates with friends through XR devices, acceptable and desirable. Similarly in such contexts, stakeholders may be more willing to find ethical more innovative

uses of XR technologies for which there is not much research if it could make children's situation better.

In terms of developmental, physical, and behavioral impacts, again there are situations where this aggregate dimension could deem a use unethical. For example, XR technologies that do not include measures to prevent users running into furniture or other obstacles would not be acceptable. Children's age is one key area where this aggregate dimension interacts with others in the grounded model. As children get older, for example, they may be better able to distinguish what is real and what is not when using XR systems.

Finally, the aggregate dimension of broad concerns for emerging technology also interacts with all the other aggregate dimensions. It can also result in some uses being considered unethical without consideration of other groups in the grounded model. For example, emerging uses of XR combined with generative artificial intelligence could enable an adult user to impersonate a child without permission, something that would always be considered unethical.

Walkthroughs can be useful in understanding how the grounded model works. Let us consider the example of a 7-year-old child using a headset with augmented reality capabilities to communicate with a parent while on a long road trip with their other parent. In terms of data considerations, the content of the XR experience would be appropriate and some concerns about privacy (e.g., mapping of a bedroom) would be lessened by the interaction occurring in a vehicle instead of inside a home. Because that parent is currently not available to the child and is unlikely to be available for some time, it is appropriate to communicate virtually rather than in person. The use of augmented reality rather than virtual reality would still enable the child to be aware of their surroundings and their other parent, another positive. In terms of developmental, physical, and behavioral impacts, a key consideration would be whether the device is safe for 7-year-old children to use. Current devices, for example, are not designed for children that age. As far as broad concerns about emerging technologies, there could be considerations about children developing expectations that their parents can always be present virtually, when not there in person, which could potentially hinder children's independence.

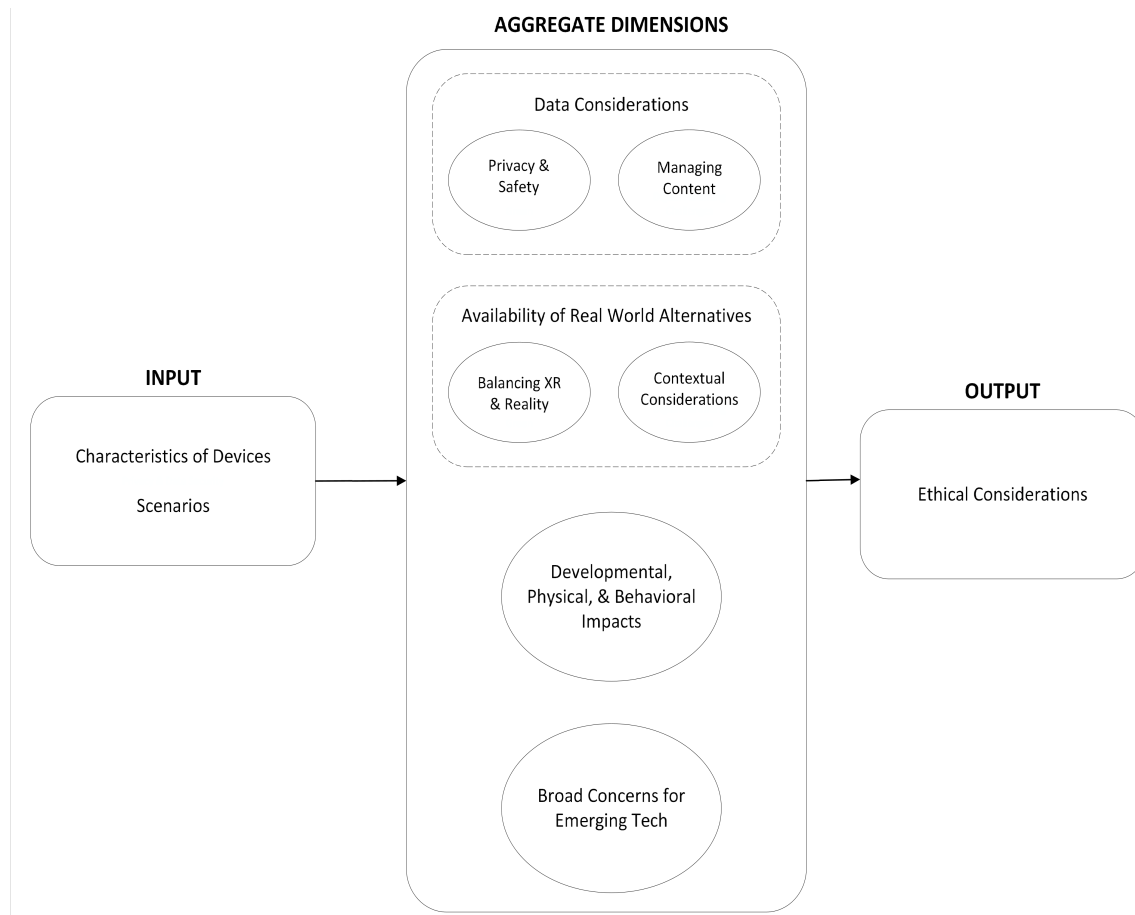


Figure 7: Grounded model.

6 DISCUSSION

6.1 What Was Different?

6.1.1 With Respect to Ethics of Technologies for Children.

Existing Frameworks. Discussions of ethics and children’s technologies are nothing new. The Alliance for Childhood, for example, released a report in 2001 [5] outlining a set of concerns about children’s use of computers. The themes of that report included risks to children’s physical health (e.g., vision), emotional and social development (e.g., isolation), creativity and intellectual development, and moral development (e.g., through inappropriate content) [5]. Concerns with regard to mobile devices have added issues of privacy and addiction to devices, driven by dark patterns and certain business models [32, 33]. These concerns were all reflected in the discussions we had with stakeholders, but there were also differences mainly due to specifics about XR experiences, which we discuss in subsection 6.1.1.2..

Another relevant framework is UNICEF’s *Responsible Innovation in Technology for Children* report focused on aspirational aspects of well-being related to digital experiences which included competence (i.e., children should feel they become more competent), emotional regulation (e.g., use of technology to relax), self-actualization

(e.g., instill a sense of purpose and self-confidence), empowerment (e.g., experience autonomy and control), social connection, creativity, safety and security, and diversity, equity, and inclusion [82]. In this case, differences have mainly to do with UNICEF’s report being mainly aspirational and based on the opinions mostly of teenage children, not involving young children in the process. However, competence, emotional regulation, self-actualization, social connection, and creativity would fit under our model’s “developmental, physical, and behavioral impacts” group, and safety and security under our model’s “data considerations” group. It is interesting to note the differing perspectives between the UNICEF report’s theme of empowerment (where children want control over their digital experiences) and our model’s view from an adult perspective of parental controls under our “data considerations” group. These, we believe, are mainly due to teenagers being the main contributors to the UNICEF report while our stakeholders were mainly thinking of 2-5-year-old children and acknowledged there would be less control and more empowerment for older children.

Interestingly, none of these frameworks emphasized contextual considerations, which were a key aggregate dimension in our analysis. Neither did they address aspects regarding the unknowns that are related to emerging technologies, other than the fact that

under our model, concerns about diversity, equity, and inclusion (from UNICEF's report) did come up as worries that higher-income families would be more likely to make the most out of future uses of XR technologies.

Specific XR Concerns. Other aspects that are different about our model have to do with the potential of XR technologies to amplify already-existing concerns about children and technologies, with some considerations that are more specific to XR technologies and to the fact that they are an emerging technology with respect to young children.

In terms of amplifying concerns, we found that stakeholders were concerned about the broad range of data needed for some XR systems to function, which go significantly beyond what smartphones, for example, can gather. Likewise, due to the immersive qualities of XR devices, the impact of inappropriate content or interactions with others could also be amplified. Even concerns about physical safety would fall under this category, with XR devices going beyond, for example, physical concerns related to video games played on a television.

As far as considerations more specific to XR technologies, perhaps the most interesting one had to do with stakeholder preference for real world experiences if they were reasonably available. On the other hand, one characteristic of desirable uses of XR that came out of our sessions was for beneficial experiences that are otherwise not reasonably available to children in their current context. For example, there was a preference for in-person educational experiences (e.g., going to a planetarium), but if the experience was not available to children (e.g., children in a rural area), then stakeholders viewed it in a positive light.

A novel concern that applies at the intersection of XR and generative artificial intelligence had to do with authenticity. With young children, the concern was exacerbated in that it need not involve any intention of making children believe that something virtual is real but may play a role in the process young children follow to learn to distinguish fiction from reality [47]. There is a related concern, given the detailed data some devices may collect about users (e.g., facial scans and monitoring of facial expressions), of models of children being used outside of their control and/or for inappropriate purposes.

Another area in common with generative artificial intelligence is the emerging nature of XR's use among children, which for stakeholders brought a fair amount of uncertainty. There was a sense of lacking proper guidance on how to best approach these novel technologies due to research not being available on their impact, or difficulties in accessing what information is available in a manner that is actionable.

6.1.2 With Respect to Ethics of Technologies for Adults. In terms of differences with issues that may affect adults, these were more prominent in a few of the aggregate dimensions. There were some clear differences, for example, under the managing content dimension, whereas stakeholders were concerned about inappropriate content, interactions over social media, and favored parental controls for young children. Another obvious dimension for differences was the one about developmental, physical, and behavioral impacts. For example, the impact on developing motor and sensory abilities

may not be as much of a concern for adults. In terms of balancing XR and reality, there would be less of a concern for adults in distinguishing what is real and what is not.

Contextual considerations also had aspects that were specific or more relevant to young children. Examples include the important place education has in children's lives and the roles of responsible adults. These differences also drove the applications that were broadly seen as positive, such as those related to education and medical care.

Overall, the research we presented makes a case for the importance of considering children when discussing the ethics of emerging technologies, as well as focusing on the specific characteristics of these technologies.

6.2 The Role of Context

While not surprising, the importance of the role of context in the discussions we had with stakeholders was very high. Except for extreme and obvious situations typically related to safety, such as those described in section 5.7, for most uses of XR, context was a deciding factor on whether use was considered ethical. Unusual circumstances, such as hospitalizations and long road trips can turn what would typically be considered negative XR uses into positive or acceptable uses. Take for example using headsets to distract children from the environment around them. In most cases, stakeholders would not think positively of such a use, as they prefer that those children be engaged with the social and physical space around them. However, if the context is that children are receiving medical treatment that could cause stress and anxiety, then stakeholders wholeheartedly support the use of XR devices to distract children.

The other context-related concept that we would like to reiterate because it kept being brought up by stakeholders was the availability of a similar beneficial experience in the real world. If a similar experience could be reasonably available in the real world, then stakeholders had a strong preference for the real-world experience. However, in situations where a temporary context (e.g., a storm) or a more permanent context (e.g., living in a rural area) makes it such that a particular beneficial experience is not reasonably available in person, then stakeholders found the virtual version either positive or acceptable. Including participants from small towns and rural areas helped highlight these potential uses for XR technologies given the lower availability of certain educational (e.g., museums) and medical resources, for example.

The centrality of context brings up interesting implications for design methods. In a significant portion of child-computer interaction research, our community conducts research either in labs at research institutions or at the schools children attend. While there are plenty of examples of other locations (e.g., outdoors, hospitals, homes), perhaps greater efforts need to be made to think more broadly about context in our design processes and evaluations, including more locations (e.g., rural areas, locations in the global south), but also more unusual situations. Such approaches could help us focus not just on supporting children accomplishing tasks but could open new opportunities by addressing a broader range of contexts.

Beyond exploring more situations and locations, our study suggests some fruitful directions for the use of XR technologies with children, as long as the hardware is age appropriate. One area for future research would include using XR technologies to make educational experiences available that could otherwise not be available. These could include virtually visiting museums, other parts of the world (or space!), historical simulations, and visualizations of three-dimensional artifacts. Perhaps due to having health professionals among our participants, medical applications were the other space where participants saw opportunities to benefit children, from virtual visits with health professionals (when appropriate) by children in rural areas, to enabling children to remain connected when hospitalized, to using XR experiences to distract children during medical procedures.

6.3 Limitations

The research conducted involved a relatively small number of participants, all adults. While research sessions occurred in two sites, including a rural one, participants all came from the same state in the United States, giving us a limited geographic sample. For these reasons, the research presented in this paper is part of a broader effort where similar activities are being conducted across five other sites in the United States, which will include children. These activities will be followed by a representative survey of stakeholders in the United States to address issues with self-selection of participants in participatory research. At that point, we will feel more comfortable developing a detailed list of ethical considerations for use in the United States. Obviously, ethical issues with respect to emerging technologies such as XR are a global issue and there is also a need to expand similar efforts around the world. This effort is limited the United States due to funding constraints.

Another limitation is that the participants in this study were largely speculating about what could happen with future uses of XR. We believe it is valuable to consider risks and opportunities before a technology becomes widely available, but the nature of emerging technologies means that activities such as those presented in this paper would ideally have to be repeated on a regular basis as XR uses by children become more concrete.

7 CONCLUSION

In this paper, we presented the outcomes of participatory activities with adult stakeholders to consider the ethics of XR technologies, focusing on young children and rural children as users. The sessions involved a broad range of activities including exposing stakeholders to ethical considerations of technologies, considering a wide set of use scenarios, trying out existing XR headsets, and carefully explaining how the systems worked. We pursued a qualitative inductive approach to process notes from these sessions, resulting in a data structure and a grounded model. These provide a first step toward identifying the dimensions involved in considering the ethics of XR technologies for children, which may also be relevant to other emerging technologies, such as generative artificial intelligence.

8 SELECTION AND PARTICIPATION OF CHILDREN

No children participated in the research.

ACKNOWLEDGMENTS

The research was funded by an unrestricted gift from Reality Labs Research.

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