FUTURE OF CHILDHOOD

Immersive Media and Child Development

Synthesis of a cross-sectoral meeting on virtual, augmented, and mixed reality and young children

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CONTENTS

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FOREWORD

By Ruth Wylie and Ed Finn
Arizona State University

Parents everywhere know the truth in William Gibson's observation: the future is already here, it's just not evenly distributed. Today a young child might encounter a wooden block, or a smartphone, or a VR headset, and that child's caregivers and educators have to make important choices about how that thing can fit into a nurturing home and empowering learning environment. Sometimes, the child knows more about emerging technologies than the parent, and yet we expect the grownups to navigate an increasingly complex technology environment that was, far too often, never designed with children in mind.

Technological change is happening so rapidly that it is rare to proactively consider its consequences for families and children. It is even more unusual when a group of experts in the subject are able to come together for a day and half to engage in conversations about the future and to develop best practices and research ideas for a growing industry. And so we at the Center for Science and the Imagination at Arizona State University were delighted to partner with the Joan Ganz Cooney Center at Sesame Workshop and Dubit to host a salon around the future of childhood and immersive media. The convening was an opportunity to learn from leading experts from a variety of fields (e.g., academia, media, medicine, philanthropy, journalism) as well a chance to create optimistic visions of the near future through a set of small-group interactive sessions. These activities encouraged participants to think critically about the future of childhood and the importance of immersive media in education, play, and everyday life. Importantly, the groups were encouraged to consider not only the technical possibilities of immersive media but also the positive and negative impact these media may have on children, their parents, and their communities.

One of the most significant outcomes of the gathering, in our opinion, was actively engaging this diverse group of experts to think about the future of immersive media together, framing the exercise directly around the children and families who will be living in this world. The questions that we wrestled with were not only "how?" but also "why?" and "should we?" The visions of the future each group shared embraced the power of these media to reduce the digital divide, create more equitable environments, and empower young children. That, at least, is what we all said we'd like to see. Many of the significant choices in ethical development and design will be made by you, the readers of this report.

We left the salon with a feeling of hope and excitement for a future where immersive media are used to enable classrooms to visit foreign countries through virtual field trips, where children in hospitals become less fearful of upcoming procedures because of a mixed reality experience, and where an augmented reality platform can cultivate a child's imagination. It's up to all of us to make that better future a reality.

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INTRODUCTION

On November 7 and 8, 2018, the Joan Ganz Cooney Center, Dubit, and Arizona State University's Center for Science and the Imagination and School for the Future of Innovation in Society convened 60 experts at the inaugural **Future of Childhood Salon on Immersive Media and Child Development** at Arizona State University. These leaders in education, research, pediatric medicine, technology policy, content creation, software development, and hardware engineering came together to contemplate the potential benefits and risks of immersive media (i.e., augmented, virtual, mixed, and cross reality) to young children. This salon comes at a pivotal time when immersive media are becoming more affordable and accessible to consumers, yet different hardware manufacturers and software companies still recommend that children under age 13 not use their systems and content. The purpose of this convening was to plan, envision, and think deeply about immersive media and child development before these media become ubiquitous in children's lives.

This report presents a synthesis of the one-and-a-half-day meeting's discussions, presentations, and hands-on work, including the most significant ideas and common themes that emerged. It also introduces participants' reflections on potential best practices and considerations for different sectors (i.e., design, research, policy, funding). By contemplating these issues now, our goal is to ensure that when it comes to young children and immersive media, we (a) understand the effects before deploying these hardware, software, and content widely; (b) develop best practice guidelines; and (c) design immersive media hardware, software, and content that take into account children and their development.

To influence the future of childhood positively, it is crucial that we individually and collectively work toward understanding and building media and technology for young children by keeping their physical, cognitive, and socio-emotional development, their diverse lived experiences, and ethical issues in mind.

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FOCUS AND APPROACH FOR THE SALON

Immersive media

There are many forms of media with which people can engage today. Magazines, movies, video games, music, and mobile applications all fall under the banner of "media," a term we use in this report to include both the content delivered and the material or technology delivering that content.

Immersion—or "the extent to which [a] system presents a vivid virtual environment while shutting out physical reality" (Cummings & Bailenson, 2016, p. 2)—can happen with any medium. A powerful book or television show can cause someone to slip into a created world, a psychological experience of "being there" called presence. While books and TV shows can provide stories that make the reader or viewer feel as if he or she is really there, systems that are *more immersive* are more likely to cause an individual to feel *present* and to stimulate his or her responses more than unmediated, physical reality (Cummings and Bailenson, 2016).

A system is considered to be more immersive if, in addition to delivering plots and narratives, it (a) provides realistic simulations with multiple sensory outputs and (b) precisely links users' physical and virtual actions (Slater & Wilbur, 1997). These more immersive media can remarkably "[blur] the lines" between "storyteller and audience, illusion and reality," giving them incredible impact and power over users (Rose, 2015, p. 3).

At the salon and, therefore, in this report, we use the term ***immersive media*** to specifically refer to the content, software, and hardware associated with augmented reality (AR), virtual reality (VR), mixed reality (MR), and cross reality (XR):

+ **Augmented reality** involves experiences in which the real, physical world is augmented, overlaid with, or supplemented by technology-generated imagery, like sound, video, or graphics. Popular AR software examples include Snapchat and Niantic's Pokémon GO, which can be supported by hardware like a typical smartphone.

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+ **Virtual reality** is a more immersive experience in which technology produces sensory output like sounds and images to create an imaginary world or one that mirrors a real environment. Typically VR engagement requires specially designed headsets. Leading VR technologies include Facebook's Oculus Rift, Google Cardboard, Nintendo Labo VR Kit, Sony Playstation VR, HTC Vive, and Samsung Gear VR.

+ **Mixed reality** is similar to AR; however, users can interact with technology-generated imagery as if it is really in the physical world, and these interactions and reactions happen in real time. Magic Leap One and Microsoft HoloLens are currently some of the most well-known MR systems.

+ **Cross reality** involves any system that combines the hardware and software of AR, VR, and MR. In the future, the ways people interact with the virtual and real world may be more "seamless, frictionless, and continuous," not delineated by the specific bounds of AR, VR, and MR (Somasegar & Lian, 2017).

Children

When we refer to ***children*** and ***child development*** here, we are focusing on children under age 13, their diverse physical, cognitive, and socio-emotional needs, and the contexts in which their growth occurs. While children still mature well into their teen years, within digital and social media environments, age 13 has come to be accepted as a watershed for independence. The United States Children's Online Privacy Protection Act (COPPA) (Federal Trade Commission, 2018) particularly aims to protect children under 13 by putting parents in control of their young children's online information. To comply with this law, immersive media software companies either do not allow children under 13 to use their products (e.g., Snap Inc., 2019) or require parental consent for their young children's use (e.g., Niantic, 2018). Likely due to a lack of understanding about any negative repercussions on children's health and safety, many immersive media hardware companies have specified that their products are not for children under age 12 (e.g., Sony Interactive Entertainment, 2018) or 13 (e.g., Samsung, 2019; Oculus, 2018), and older children should not use their products without adult supervision (e.g., HTC, 2019).

These age restrictions disrupt the common historical narrative of how new media and technology are often introduced to the public. Historically, younger children have been targeted as potentially profitable consumers as new media are designed, developed, and distributed. As with television, home computers, and the internet, marketers' first instinct is to advertise these media as being great—or even *vital*—for young people's education, as a way to get families to buy into them. Yet, in these past instances, there was actually no deep consideration during development about the benefits or drawbacks of hardware, software, and content for children, like how the media might enhance or detract from children's learning or experiences in new ways. In most cases, once the advertised media reach enough homes, the focus on children fades into the background because content for adult audiences is more lucrative. (For more information on this marketing pattern with children, see Ito, 2012; Pecora, 1998; and Wartella & Jennings, 2000.)

With immersive media, if we are proactive and intentional, researchers can study the effects of hardware, software, and content for children, and practitioners can develop standards and guidelines for development, *before* immersive media are marketed toward and released broadly to children.

Immersive media + children

We organized this salon to seize the opportunities described above. We wanted to gather a multi-disciplinary group of experts before these media are more widely available to children, to consider the affordances and potential negative effects of immersive media hardware, software, and content in the context of children's development, play, and learning.

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SIDEBAR: RESEARCH ON CHILDREN AND IMMERSIVE MEDIA

Some researchers have been studying immersive media and children in various contexts already.

For instance, researchers have examined the effects of immersive media on the following:

Children with disabilities or those in medical settings, e.g.:
+ Boyd, Day, et al., 2018
+ Boyd, Gupta, et al., 2018
+ Gold et al., 2006
+ Kientz et al., 2014
+ Li et al., 2011
+ Won et al., 2017

Children's education and learning, e.g.:
+ Castaneda & Pacampara, 2016
+ Johnson-Glenberg, 2018
+ Lindgren & Johnson-Glenberg, 2013
+ Radu, 2014

Children's physical safety/health, e.g.:
+ Koulieris et al., 2017
+ Patney et al., 2018
+ Yamada-Rice et al., 2017

Children's perspective-taking, e.g.:
+ Bindman et al., 2018
+ van Loon et al., 2018

This list is not exhaustive—see Bailey & Bailenson, 2017, for a review of other prior related research.

As some research has already shown (Sidebar), immersive media may have unique impact on children (both positive and negative) because, developmentally, they are less capable of distinguishing what is real from what is not real compared to adults (Bruck & Ceci, 1999; Flavell, 1985; Foley & Johnson, 1985; Foley, Santini, & Sopasakis, 1989; Lindsay, 2002; Lindsay, Johnson, & Kwon, 1991). With the added layer of *presence*, content delivered through immersive systems could exacerbate children's challenges with this differentiation, making immersive media messages potentially more *harmful* or *beneficial* due to their prospective realism. With this realism in mind, immersive media have the potential to affect children's imagination, empathy or perspective-taking, and experiential, embodied learning differently and more intensely than other types of media experiences.

Moreover, immersive media might change the conversation about equitable access, participation, and inclusion for children. These media are altering the landscape of where children can "go" and what they can "do" by giving children opportunities to take field trips around the world, travel back in time, experience what it is like to "be" another person, and even work with rare science materials. With equitable access to equipment and high-quality content, otherwise disempowered children may be able to learn and participate in experiences that they would not typically be able to engage in. Here, we see a chance to empower more children with immersive media.

Taking into account these ideas and background research, we are in the position to speculate, plan, evaluate, and reflect on immersive media for children before they become pervasive in their lives. Plus, rather than research prototypes, we have industry-developed systems and content that are widely, commercially available for adults, which we can use in studies with children in labs, at home, and at school. By gaining a deeper understanding of the opportunities and risks of these powerful media—their hardware, software, and content—from multi-disciplinary positions, we can be more proactive individually and collectively about ensuring that immersive media are thoughtfully designed and that children engage with them productively and safely.

The approach

We took a future-oriented approach (i.e., 10-year horizon) to our activities at the salon. This allowed participants to share ideas without worrying about details or constraints of today—or even tomorrow—that might limit one's perspective. So often, when we consider the future (especially with new media and technologies), we imagine dystopian or utopian extremes. At this meeting, we envisioned positive futures together, grounded

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in the knowledge, practice, and pragmatism of participants and inspired by their creativity. The purpose of these aspirational yet achievable visions was not to predict the future, but rather drive where we want our future to go.

Participants included approximately 60 leaders from academia, media industries, medicine, education, philanthropy, and journalism representing nonprofits, studios, universities, large technology companies, and more (see Appendix). We were able to gain a more holistic, cross-disciplinary perspective from these participants due to their diverse knowledge, experience, and positions on the possibilities for and concerns about immersive media and child development.

To prepare participants for the salon, we produced a framing paper and five field experts wrote vision papers (Appendix A) describing their visions of immersive media in 10 years and the role these media will play in shaping childhood. The salon itself involved a series of short talks, small and whole group discussions, demos, and hands-on breakout sessions centered on immersive media and child development. Together, this assortment of activities allowed participants to learn from each other and demonstrate their knowledge and ideas for the future in diverse yet complementary ways. (For the full agenda, see Appendix B.)

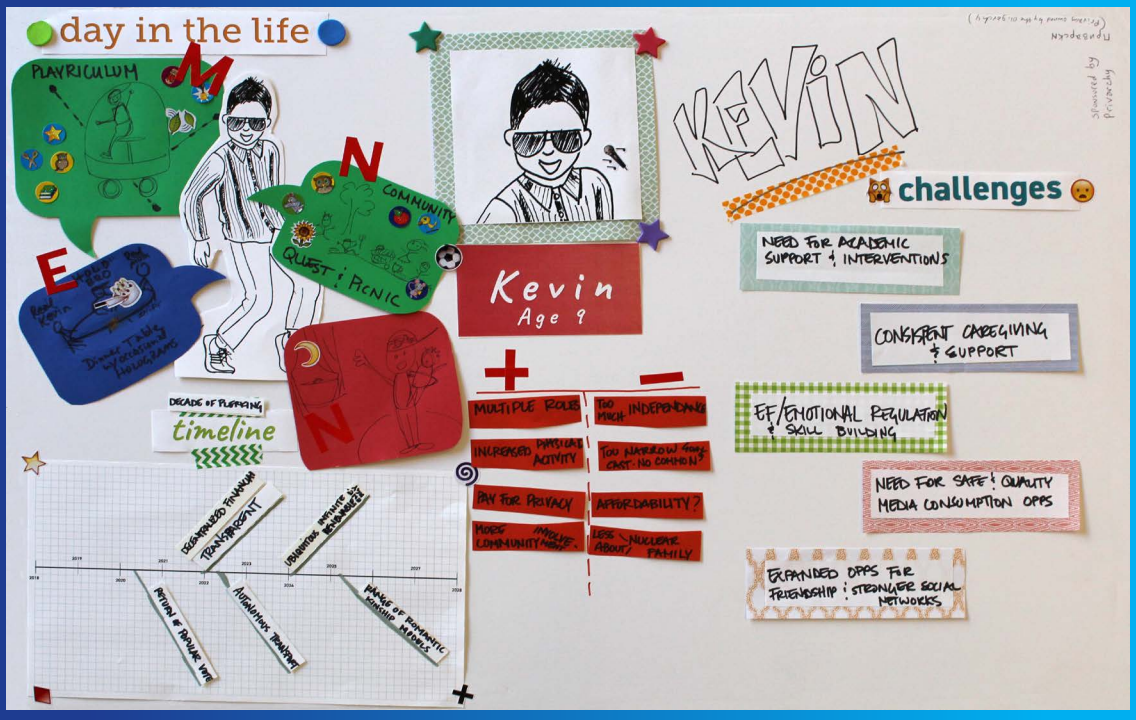

FIGURE 1

Example of a poster developed by a participant group during the hands-on breakout sessions. The poster presents (a) the child; (b) any key challenges of using immersive media productively in their life; (c) a 10-year timeline of technological, social, and cultural developments from 2018-2028; (d) a "day in the life" story that includes where the child may encounter immersive media; (e) group reflections on the implications of the future the group developed (focusing on issues of healthy development, privacy, equity, education, etc.); and (f) any research questions or programs that need to be explored based on this future.

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Short talks focused on prior research in this area and speculations about the future of childhood with immersive media (see Appendix C for speakers' short bios). Small (i.e., five participants) and whole group discussions involved brainstorming areas for researchers, policymakers, and practitioners to consider moving forward. During hands-on work, groups of five participants imagined future roles for immersive media grounded in a child profile assigned to their group. Each profile was based on a real child who one or more of the salon organizers had encountered in their research or lived experiences. These children varied in age, gender, interest, socio-economic status, ethnicity/race, culture, community setting, and cognitive, motor, communication, and social interaction skills. By building on the information about their assigned children's lives, personalities, and development, breakout groups created narratives about these children with immersive media. This process revealed positive, negative, intended, and unintended consequences of the media on children plus any research, policy, and/or practice that would need to be explored in their imagined future. In turn, this narrative method acted as a basis for discussions around the futures for which we need to prepare. (See Figure 1 for an example artifact created through participants' hands-on work.)

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MEETING SYNTHESIS

The following sections summarize what occurred during this futurist, cross-sectoral meeting on immersive media and child development. Rather than presenting the synthesis in order of the agenda (Appendix B), we do so through a set of themes that emerged over the course of the salon: (a) imagining the future of childhood, (b) considerations for design, (c) crafting a research agenda, and (d) exploring priorities for policy, advocacy, and funding.

Imagining the future of childhood with immersive media

Integral to the futurist approach of the salon, participants consistently imagined what the future of childhood might hold and what immersive media's role in that future might be. Vision papers (Appendix A) framed these conceptions, providing outlooks of a future in which children will experience different versions of reality while being physically co-present (Jeremy Bailenson); virtual experiences will be learning assessments in and of themselves (Lisa Castaneda); devices will be smaller, lighter, cordless, and integrated with brain-computing interfaces and haptics (Chris Chin); and children will be able to see, touch, and play with their imaginary friends in AR and VR (Jesse Schell).

While everyone participated in discussions and hands-on activities with this future focus, some participants gave short presentations (or "spark talks") on their visions and recommendations as well.

A balanced view

Throughout the salon, participants debated both possible benefits and drawbacks of immersive media for children. In her spark talk, Justine Cassell, Associate Dean at Carnegie Mellon University, reiterated the importance of these types of multi-faceted deliberations. She urged participants to continue to take a balanced view in imagining and shaping positive futures by "moving past optimism or pessimism" to consider the opportunities and

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challenges immersive media present to children and in what contexts these impacts hold true.

> "I'd really like us to move past optimism and pessimism and start thinking about what we do and why we do it. If we have a new technology, it's not a hammer looking for a nail. It's a set of opportunities and challenges... It's an opportunity to think in a new way about the tasks we want children to be able to do in the real world."
>
> **Justine Cassell**

In terms of opportunities, participants imagined scenarios where immersive media could enable children to connect, play, and learn in ways they were not able to before. In the futures participants developed during their hands-on activities, children used immersive media to produce physically impossible creations, like virtual art, games, and stories. They also used immersive media to connect with non-local friends and family through rich virtual social interactions and to learn by engaging with their whole bodies in interactive simulated experiences. Along the lines of what we have learned from past research (e.g., Boyd et al., 2018; Gold et al., 2006; Won et al., 2017), in these imagined futures, immersive media were able to positively change how children approached health and well-being too. For example, these media assisted children with physical rehabilitation, helped them calm their anxieties, and otherwise supported their physical, cognitive, and socio-emotional needs.

President of Games for Change Susanna Pollack also emphasized in her presentation other contexts in which immersive media might spark "a world of wonder," providing possibilities that were not available to children before. In this world of wonder Pollack described, children could role play and try out career paths, especially those that would otherwise be impossible to try, like flying planes and building cities. Children could also experience and meet people of many cultures, in near and faraway places, and different time periods. These media might allow children to meet their role models, such as how the project *Breaking Boundaries* (Filament Games, 2018) currently enables players to meet influential women scientists in virtual reality. Children might also visit refugee camps to learn about the world's migration issues, such as how the United Nations Virtual Reality (2015) film *Clouds Over Sidra* lets viewers follow a 12-year-old throughout her day in a Syrian refugee camp in Jordan called the Za'atari camp. Yet, Pollack also made clear that these immersive learning experiences of the future would not be designed to stand alone; rather, they would be facilitated by other complementary conversations and activities with their peers, families, and teachers.

Dan Ayoub, General Manager of Education at Microsoft, Mina C. Johnson-Glenberg, Research Professor at Arizona State University, Robb Lindgren, Associate Professor at University of Illinois at Urbana-Champaign, and Pollack all presented on how immersive media might change the process of STEM learning in particular by permitting children to experience STEM principles in experiential and embodied ways. For example, children might engage in non-human experiences, like growing from a seed to a sapling to a tree from a tree's point of view, to understand environmental and other biologic processes. Using immersive media, children could also perform science experiments without expensive or dangerous consequences. This might involve working in a safe dry lab or building virtual robots without the cost of physical materials.

Ayoub also spoke about the power of immersive media to provide other novel contexts for learning in the future. For example, as evidenced in past research (e.g., Kientz et al., 2014), immersive media could help children with sensory sensitivities, specific communication needs, or particular disabilities learn by attending to their strengths, preferences, and needs in adaptive and individualized ways. He explained these media

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could also remove the fear of failure in and outside the classroom by giving children the ability to move at their own pace in their own personally customized environments. Additionally, Ayoub pointed out the potential for immersive media to transform distance learning, as the number of students who require formal education is drastically growing (e.g., UNESCO Institute for Statistics, 2015; UNESCO International Institute for Education Planning, 2017).

Participants also scrutinized how and in what contexts immersive media may present risks or not be best-suited for children. In the future scenarios they imagined during hands-on activities, immersive media sometimes presented security and privacy threats and discouraged unmediated, real life experiences. Within some groups' future narratives, these media also widened digital divides when their child profiles' families could not access immersive media hardware or content. Later, participants discussed how engagement with immersive media content could be too psychologically intense for children and how this content, because of its perceptual realism, might cause confusion between facts and fiction. In his presentation, Alan Gershenfeld, Co-Founder and President of E-Line Media, introduced Keiichi Matsuda's provocative concept film *Hyper-Reality*, which depicts a future in which virtual and physical realities are intertwined, and the environment is entirely media-saturated (Keiichi Matsuda Ltd., 2016). This critical case study helped participants imagine an overwhelming new reality with sensory overload and powerful behavior change mechanisms, which would be difficult for children to navigate.

Moving these types of conversations forward, in his spark talk, Michael Rich, MD, MPH, of the Center on Media and Child Health at Boston Children's Hospital introduced three specific concerns for children based what we know about immersive media today. First, immersive media may be unsafe for children due to the cognitive load these types of media put on children's brains. This is because the prefrontal cortex, which is connected to executive functions like impulse control and future thinking, is still developing for children until their mid- to late-twenties (Arain et al., 2013).

Second, due to how children learn and explore the world, including the physical, the social, and the emotional, through their senses—sight, hearing, smell, touch, proprioception and, for young children, taste—we must think about what it means for immersive media to simulate these sensations for children. Currently, we do not understand the consequences of blurring humans', and especially still-developing children's, visions of reality. As Rich described, the concern is that if immersive media can make anything possible through realistic simulations, delivering pre-processed sensory information on demand, children's brains may be "irreversibly altered toward the entitled, incurious, and passive."

PROPRIOCEPTION

Proprioception, also known as kinesthesia, is the conscious and unconscious awareness of one's body position/orientation and movement in space. This includes a person's sense of equilibrium and balance. Proprioception enables you to touch your finger to your nose when your eyes are closed, and makes sure you don't lose your balance when you move from hard concrete to soft grass when walking.

Third, Rich similarly explained that immersive media should be a part—not all—of a rich and diverse menu of experiences for children. In this way, immersive media should not replace children's experiences in the physical, unmediated world but instead be a springboard for children's engagement with the unmediated world "with imagination, playfulness, and risk-taking." These media should allow children to "connect with others in deep, authentic ways" with and without technology and to approach the world and the problems they encounter with "a critical mind, creative spirit, and empathetic heart."

A zoomed-out view

While participants and speakers proposed a *balanced view* of how immersive media may affect our children in the future, during his spark talk, Gershenfeld took a broader, zoomed-out

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approach in imagining the future of childhood with immersive media. Drawing on the narrative practice of worldbuilding (see World Building Institute, 2019, for more details), Gershenfeld emphasized that, in reflecting on the future of childhood, we need to think about the greater context of immersive media use. Here, the purpose is to reflect not only on how immersive media will shape the the world (including childhood) but also on how immersive media will be shaped *by the world*. In this way, it is crucial to look across broad trends, to uncover where we have individual and collective agency to shape these trends, and where we have to adapt them. Following this idea, during one hands-on breakout session ("Worldbuilding"), participant groups produced 10-year-long timelines from now until 2028 that contained fictional (but possible) major world events, including technology innovations, natural disasters, and political movements, which could alter immersive media's place in the future, how they are designed, and how people will engage with them.

"You have to look at the whole world holistically, and that raises an interesting question... which is not how we will shape AR and VR—that's critical—but how will they be shaped by forces outside our control and how much can we start to think about those [forces] and get ahead of the curve."

Alan Gershenfeld

Gershenfeld asked participants to contemplate today's trends in the digital gaming industry to help them envision what is in store for and/or how we can shape immersive media. His examples of gaming industry trends included:

+ the business model of content creators: largely a free-to-play economy that involves in-app purchases, lots of advertising, and powerful, and sometimes unethical, behavior change mechanisms to keep people playing;
+ the democratization of content creation: theoretically anyone can put an app into the app store, which gives users more options yet makes finding high-quality content among the many options more difficult;
+ the discovery of content by users: many games to navigate; algorithms change what children see, want, and buy;
+ the global appeal of games: a world market and growing consolidation of the industry;
+ genres of popular games, such as open-world, sandbox building games like Minecraft and cooperative battle royale cross-platform games like Fortnite Battle Royale; and
+ the impact on the kinds of jobs children want—for example, some children want to be professional gamers.

Reflecting on one of these digital gaming industry trends, David Kleeman, Senior Vice President of Global Trends at Dubit, debated how applying the current business model of free-to-play games to immersive media content may complicate how children will engage with these media. Kleeman explained that we need to aim for fairness (for children and parents) and sustainability (for developers) to produce a situation in which families can access quality immersive media content and developers can make a fair living to produce this quality content.

Gershenfeld zoomed out even further to look across global technological trends that might also shape how immersive media will be designed and how children will interact with these media: artificial intelligence, infrastructure (e.g., 5G), biometrics, digital fabrication, regulation, and distributed ledger technology (e.g., blockchain).

Creating immersive media: Considerations for design

Throughout the salon, participants brainstormed and reflected on their research, practice, and hands-on activities to inform immersive media design for children. Below we describe five main

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areas participants explored that may be salient for the design of safe and productive immersive media for children.

1: Physical and psychological implications
First and foremost, participants agreed immersive media hardware, software, and content must seriously take into account children's physical safety. During a small group discussion on immersive media hardware, participants brought up ergonomics, fit, and form as consequential topics for physically safe designs. They emphasized how headsets' size and weight, visual placement (i.e., pupil inter-distance, or PID, settings), and hygiene are all important to consider when designing physically safe systems for children. They also discussed the different physical safety issues that come with various types of modalities (e.g., tethered or untethered systems) and the benefits of using controller straps to ensure that controllers do not slip out of users' hands.

In her presentation, Cindy Ball, Program Manager of Oculus Education (whose products and platform are only for users age 13+), spoke about specific physical safety considerations for virtual reality hardware development. Ball explained that designers making such experiences need to think about the surrounding environment of immersive media use, such as the openness of the space and the possibility of people or animals moving in/out of the environment. Currently, Oculus takes these types of physical safety considerations into account for its user base with their Oculus Guardian System. This system prompts users to set up play boundaries in VR based on the physical environment and reminds users of physical obstacles by revealing a translucent wall in VR when boundaries are reached. To further guide users on safety, Oculus rates its online store content according to the levels of movement, activity, and intensity involved in each VR experience.

Moving the conversation to augmented reality, Jason Yip, Assistant Professor at the University of Washington, discussed parents' physical safety concerns for their children who play location-based AR games. In an interview- and survey-based study he ran on this topic (Sobel et al., 2017), Yip found parents appreciated the opportunity for their family to exercise, learn

PHYSICAL DESIGN GUIDELINES FOR ADULTS

Some VR and AR companies have released guides to help developers create safe and comfortable content and hardware for their users, which may provide inspiration for designing for younger children, but are not for children per se.

Google (2019) offers VR content designers and developers Designing for Google Cardboard, which discusses physiological considerations for design and guidelines to help users avoid experiencing simulator sickness.

Oculus (2019) provides content designers and developers with their own guide, VR Best Practices. These best practices overview general user experience, vision display, locomotion, position tracking, and more to ensure their users (age 13+) have safe, comfortable, and enjoyable experiences in VR. In its "Additional Reading" section, this guide also lists numerous academic research papers that address ergonomics and simulator sickness.

Intel published Guidelines for Immersive Reality Experiences (Michalak, 2017), which has a section devoted to "physical foundation," including hardware ergonomics and both physical and social safety.

Leap Motion (2016) similarly reviews guidelines for ergonomics, spatial layouts, and avoiding simulator sickness in its own blog post.

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about their environment, and connect with each other while playing Pokémon GO, a location-based AR game. However, parents also worried about their children getting distracted and hurt outdoors and interacting unsafely with strangers while playing the game. Although parents came up with their own rules for managing children's physical safety in this context, this study suggested AR systems and content could include features that thoughtfully address caretakers' values and concerns.

"I don't want my kids to be the dumb dumbs who fall off a cliff or [get] run over by a car because they [are] too engaged."

Quote of mother in Yip's study (Sobel et al., 2017)

In addition to physical safety, salon participants also reflected on the potential psychological impacts of immersive media on children. Psychological considerations are especially critical for immersive media design because children, at certain ages, may not be able to separate reality from virtuality (e.g., Segovia & Bailenson, 2009), increasinging the power and salience these media may hold in attracting children's attention and changing their behavior. In a presentation, Jakki Bailey, Assistant Professor at the University of Texas at Austin, reviewed immersive media's potential positive and negative psychological implications for children. Giving an example from her own research with young children and a life-size Grover, who is a popular *Sesame Street* character, in VR (Bailey, 2017), Bailey explained that due to its perceptual realism, VR can be can be socially rich but also overwhelming for children. Immersive media can also be powerful in eliciting presence and blocking out the unmediated, physical world, which may be helpful as, for example, a pain distraction tool for children with specific medical needs (e.g., Gold et al., 2006; Won et al., 2017), but also draw children away from the unmediated, physical world. Bailey also suggested immersive media content moderate a balance between real and fictive relationships, so that emotional connections in the virtual space do not supercede human relationships.

Connecting both physical safety and psychological effects of immersive media, participants also discussed how natural stopping points and supports for time constraints in immersive media content (e.g., content that encourages short bursts of play or asynchronous play; built-in prompts to stop playing after an extended time period) might benefit children. Whether hard-coded, manually set, or adaptively guided by artificial intelligence, this inclusion may ensure that children are more protected physically, cognitively, and socio-emotionally. Natural stopping points and supports for time constraints may enable children to have opportunities to safely and seamlessly transition between realities and reflect on their virtual experiences. These constraints may also support children in crossing boundaries (Takeuchi & Stevens, 2011), giving them time to connect their virtual experiences with those in the unmediated world. Additionally, considerations for time may safeguard children from being isolated from the outside, unmediated world, as opposed to encouraging constant virtual connectivity.

2: The right medium for the message?

Across their presentations, discussions, and activities, participants also questioned whether or not immersive media engagement is truly the appropriate medium for the messages trying to be sent to children. Participants pointed out that just because something is possible with immersive media does not mean that it is appropriate for children.

In her presentation, Cassell asked for explicit reflection on the purposes for designing immersive media content for and using immersive media systems with children: what do we want to do with immersive media and why? She explained immersive media are not hammers looking for nails; rather, augmented, virtual, mixed, and cross realities give us the ability to carry out tasks that are not possible to do in the physical, unmediated world with a potentially more diverse population of children. Therefore, Cassell challenged participants to think beyond either an ideal or damaging technology to one that

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would be best for certain imperatives or goals within particular contexts.

Kleeman agreed with these sentiments, explaining in his own presentation that if these media do only what our current devices do, then it will not make sense to have immersive media systems in the future of childhood. Alternatively, he explained, immersive media have to do things differently and/or better than the media and technologies we already have, rather than being just another platform to watch TV, play games, or learn in the same ways as before.

Following these speakers' provocations, participants deliberated in what situations the affordances of immersive media systems and content may be uniquely suited to children's needs, such as Bailey's example of pain distraction, and when another medium may be more suitable. In a whole group discussion, Nancy Jennings, Associate Professor at the University of Cincinnati, suggested another appropriate domain for immersive media and children: these media might give children opportunities to explore their identities in new ways and understand others' identities as well (keeping in mind that first-person simulations may still perpetuate stereotypes of marginalized identities; see Lee, Nass, & Bailenson, 2014; Nario-Redmond, Gospodinov, & Cobb, 2017).

To help determine whether immersive media are *right* for the message, Johnson-Glenberg brought up Jeremy Bailenson's argument that there are only four situations where virtual reality is appropriate. These four situations (Bailenson, 2018) occur when, without VR in the unmediated, physical world, they would be:

1. *impossible* (e.g., breaking the laws of physics or inhabiting avatars with different skin colors to reduce implicit biases; Hasler, Spanlang, & Slater, 2017),
2. *expensive* (e.g., taking a classroom to another country),
3. *dangerous* (e.g., working with physically harmful materials in a science lab), or
4. *counterproductive* (e.g., cutting down a forest to learn about deforestation).

Building on these situations, Johnson-Glenberg (2018) offered three more constraints for when virtual reality or immersive media would be appropriate for children:

1. when the *third dimension is integral* to the phenomenon (e.g., learning about content that exists in three-dimensional space, like electromagnetic waves);
2. when users would *benefit from being "agentic"* or being able to explore and manipulate content directly from their own point of view with their own body and hands (e.g., perform a science experiment, rather than observe it being done); and
3. when the feeling of experiencing the virtual as real, or *presence, adds a profound layer* (e.g., exploring and interacting with content as if you are actually there through immersive media engagement may increase understanding compared to only watching content) .

Together, these seven considerations may help designers create appropriate content for children.

3: Content appropriation & how children interact, think, and learn

When speaking about immersive media content, Kleeman made clear that this content should target children's tenth use, not only trigger their anticipation for future engagement nor only engage them one or two times. To sustain children's ongoing meaningful participation, salon participants contemplated how immersive media content could be kept flexible or open-ended to allow children to appropriate these experiences in the ways that they want or need. Cassell expressed that we should expect—or perhaps even require—children and families to appropriate immersive media to match their own values and goals. And to support this imperative, instead of immersive media content having only one use, she explained, engagement should allow for a multiplicity of uses, where children can be producers and not just consumers of the content. In this way, immersive media could enable children to engage with their bodies and minds to make their experiences their own.

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"Children should be producers and not just consumers—how often have we said this, how many times are we going to need to say this with each new technology?"

Justine Cassell

Building on how children might appropriate experiences, participants also thought about how immersive media content, software, and hardware can utilize the ways we know children interact with others and the world, how they think, and how they learn.

For instance, both Lindgren and Johnson-Glenberg spoke about the advantages of grounding immersive media designs in children's authentic physical and social interactions. This includes (a) extending how children actually use their hands and bodies in the physical, unmediated world to their interactions with the virtual world and (b) involving children's whole bodies as controllers, which may increase learning (e.g., Lindgren et al., 2016). During his talk, Lindgren described how children use gestures to act out their thinking physically; thus, gestures become visible metaphors for knowledge and a form of assessment of understanding. Therefore, Lindgren explained, children can use gestures during immersive media engagement to show how something works or to test hypotheses, like making predictions of where an asteroid will go. Similarly, in her presentation, Johnson-Glenberg gave other specific guidelines for gestures: hand controls should be used for active, body-based learning; gestures should be performed from a first-person point of view (i.e., agentic), which may also reduce simulator sickness; and gestures should map to children's interest in the content (Johnson-Glenberg, 2018). Overall, interactions with immersive media should be purposeful, explicit, and meaningful in context.

In addition to theories of embodied interaction and learning-by-moving, salon participants emphasized other learning theories that could be productive for immersive media content. Johnson-Glenberg specifically described a few considerations. For example, designs should scaffold children's cognitive effort and exploration (i.e., Vygotsky, 1980; Wood, Bruner, & Ross, 1976). Johnson-Glenberg suggested this may involve designs providing immediate, actionable feedback with low-stake errors. (See Johnson-Glenberg, 2018, for a complete list of guidelines.)

Additionally, following the importance of reflection for learning (Boud, Keogh, & Walker, 2013), participants spoke about how children may need opportunities for reflection during immersive media engagement, as opposed to consuming constant streams of content without any breaks. As Yip mentioned in his presentation, a benefit of augmented reality may be that it is not fully immersive, allowing for conversations around and through it (Takeuchi & Stevens, 2011). However, researchers need to study what breaking presence during immersive media experiences means for children's learning and engagement. In other words, especially in virtual reality, what are the implications of coming back to the unmediated environment in the middle of an immersive experience that feels real? Will this curtail learning because of the lack of sustained engagement? Or will it improve learning effects because of the chance to discuss and reflect on experiences? Will coming in and out of presence-inducing experiences be too stimulating for children's information and sensory processing systems, or will these breaks give such systems time to recuperate or adjust?

In a more specific case of how children learn, Curtis Wong, a pioneering media and technology designer and former Microsoft Research manager, presented a story-based or *contextual narrative* approach for learning with immersive media. Providing examples of his own projects—i.e., *A Passion for Art* (Bruckner, 1995), Commanding Heights (Heights Productions, Inc., 2002), and WorldWide Telescope (American Astronomical Society, 2018)—Wong explained the contextual narrative method (a) engages users with a story, (b) enables them to build mental models through exploratory interaction and multisensory stimuli, and (c) validates/refines these developed models with reference information and data. For example,

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with WorldWide Telescope, children can take guided virtual tours of outer space (i.e., narrative motivation), interact with objects like planets and create their own tours for others to take (i.e., contextual exploration), and reference other data and sources online (i.e., extrapolation/validation). As Wong showed, by building mental models through exploration in compelling learning environments this way, children can demonstrate deep understanding and transfer their developed interests and understanding beyond experiences with immersive media.

Furthermore, research has shown that using media together—also known as *joint media engagement*, or *JME* (Stevens & Penuel, 2010)—supports learning for children. In line with this notion, salon participants agreed children should be able to collaborate, co-create, and bond with others while using immersive media. To facilitate joint engagement, the design of content, software, and hardware should consider different perceptual views (e.g., first-person vs. third-person) and physical configurations, interactions, and gestures to support the participation of multiple users. Content could spark family conversations or drive shared family experiences and memories. Immersive media content could also support collaborative engagement by introducing mutual dependencies and common goals between or among users/players. Regarding co-creation, salon participants suggested users might cooperatively develop and tell their own stories using immersive media as well.

4: Adults in children's lives

Next, participants consistently emphasized the role of adults (e.g., parents, caregivers, teachers, librarians, etc.) in children's lives with new media and technology. Adults often choose, pay for, and provide media to their children; co-engage with media with their children; and are otherwise part of the system or context in which children engage with media (Barron, Kennedy, Takeuchi, & Fithian, 2009). In this way, adults influence how children might or can interact with immersive media and should be taken into account when designing these media for children. As Kleeman described, immersive media are more likely to appeal to parents (a) if they are interested in playing with these media with their children and (b) if they believe the media will be beneficial to (and not risky for) their children in some way, whether that be for learning, laughing, playing, socializing, or for other reasons.

As there is already growing interest in using immersive media in the classroom, salon participants also made clear how essential it is for immersive media systems to be practical, easy, and meaningful for educators. Both Ayoub and Kleeman raised points about equitable design and distribution processes that create meaningful pipelines of curricular support and training to make using immersive media viable for diverse teachers and students. These speakers also considered the benefits of integrating high-quality curricula into designs to create meaningful immersive media content. Integration of curricula should also involve making the *entire* immersive media experience simpler: setting up the system, supporting engagement with the media, and facilitating discussions and activities afterward to compare, contrast, and contextualize learners' different experiences. Teachers will also need training to help them understand scenarios in which immersive media might be best and effectively utilized in straightforward ways (e.g., not necessarily in a full class but in smaller, more easily supported environments like libraries or computer labs).

For parents, caregivers, teachers, and other people who work with children, transparency about immersive media content and its goals is also vital. As Kleeman advised in his presentation, designers should not make false promises about immersive media content. Instead, he recommended they promote their visions, curricula, and educational philosophies to empower adults with the knowledge they need to make informed decisions about whether or not, and in what contexts, the content of a particular immersive experience is appropriate for their children.

5: Other considerations for design, development, and distribution processes

Finally, participants had other significant ideas about the processes of immersive media design,

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development, and distribution. Foremost, participants highlighted how critical it is to not release immersive media to children before we better understand the risks of these media and whether they are safe for children, including when and in what contexts.

Participants then discussed the value of attending to children's diversity (i.e., age, gender, interest, socio-economic status, ethnicity/race, culture, community setting, cognitive, motor, communication, and social interaction skills, etc.) during the design process to establish equitable, meaningful immersive media hardware, software, and content. Similarly, participants discussed the benefits of involving children, parents, families, teachers, and librarians in these design processes to meet the wants and needs of these users.

Concerning equity, participants also suggested designing content for the simplest, most affordable yet still effective technology possible could help ensure diverse children can access and engage with these media. Parallelling this conversation, participants considered how distribution channels of low- and/or no-cost access and connectivity to content, software, and hardware could also lead to more equitable engagement.

Crafting a research agenda for immersive media and child development

During small and whole group activities, participants began forming a research agenda that concentrates on studying immersive media and children. Participants' ideas were based on their research, practice, expertise, and questions raised from groups' hands-on activities. These ideas were also grounded in prior research (see Sidebar for examples) but with new industry-manufactured immersive media systems and content.

While generating a research agenda, participants brought up significant challenges to conducting this research with children as well. As Lori Takeuchi, Deputy Director and Head of Research at the Joan Ganz Cooney Center, pointed out during a whole group discussion, there is still a question of how to study children's use of immersive media with currently available platforms, as we do not yet know the risks to children and their development. Researchers must reflect on the ethical implications of doing this crucial work with children and find the best, safest methods for conducting it.

Moreover, Rich reminded us that we are following three moving targets when trying to understand the impacts of new media and technology on children: children's development, a rapidly changing technology environment, and the transformation of our behavior due to having these technologies. Therefore, challenges associated with each need to be considered when doing research with immersive media and children.

In the following subsections, we summarize four pillars that participants identified as critical anchor points for an emergent research agenda concerning immersive media and children. Rather than an exhaustive list, these pillars introduce an initial framework with questions and areas of investigation to be debated, expanded, and explored further.

1: Developmentally appropriate

First, participants emphasized how research must take an evidence-based, multi-method approach to assessing immersive media's effects on children's physical, cognitive, and socio-emotional development and learning across different ages and stages.

Participants brainstormed examining the repercussions of immersive media's simulated sensory information on children's development, such as their visual systems and executive functions like impulse control. They also stressed the importance of determining how these sensory simulations are different from or the same as sensory stimuli from the real, unmediated world, in regard to children's information processing capacities.

Correspondingly, as Bailey detailed in her spark talk, it is crucial that developmental research investigates how children's age/stage-related

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abilities change how they understand and learn from immersive media too. Here, participants highlighted determining how and when children can conceptualize that immersive media experiences are fictive, and how this might change for augmented, virtual, mixed, and cross reality engagement. This research also involves discovering how children relate to content, such as virtual characters, within immersive environments, and how they transfer information from inside these environments to the outside world.

Notably, these types of investigations may have implications for design and practice. For example, they may influence the development of programs for teaching immersive literacy skills to children, best practices for introducing immersive media experiences to young, first-time users, and guidelines on how to have children safely bounce in and out of immersive environments. Studies may also help designers understand how lifelike (or unrealistic) immersive media content needs to be in order to also be compelling and productive yet not overwhelming for children.

2: Targeted at diverse populations

Participants also underscored the value in research that targets various populations (e.g., low-income, disabled, etc.) to drive equity and equal opportunity goals for immersive media. Accordingly, equity- and equality-driven research must be conducted with children and families who are diverse in age, gender, interest, socio-economic status, ethnicity/race, culture, community setting, cognitive, motor, communication, and social interaction skills, etc.

With this focus in mind, researchers can evaluate (a) the efficacy/consequences of interventions with immersive media among diverse groups of children and (b) what makes these media meaningful or valuable to these different groups. In this way, researchers can answer questions surrounding justice, such as how children in low-income vs. high-income communities engage with immersive media and how immersive media might present opportunities for enhancing equity of experiences and learning for typically marginalized groups. In these cases, research must focus on the whole child, including their different cognitive, socio-emotional, and physical abilities and needs and the different aspects of their multifaceted identities.

3: Ecologically astute

During the whole group research discussion, Sasha Barab, Executive Director of the Center for Games and Impact at Arizona State University, and Ellen Wartella, Al-Thani Professor at Northwestern University, made clear that studying what happens around immersive media systems for children is just as, if not more, important as what happens within immersive worlds. Therefore, examining children's developmental and learning ecologies across micro-, meso-, exo-, and macro-levels arose as another critical point for a research agenda in this domain (Bronfenbrenner, 1979).

Participants suggested this type of research should involve conducting ethnographic studies on the ways that children and families are using and appropriating immersive media and how these media may be changing the nature of play in the greater ecological context of their lives. Kleeman described ways that children are already making immersive media environments their own through transgressive interaction with content, such as washing hamburgers and frying menus as a gourmet chef in the virtual reality game Job Simulator. This point leads to further research questions around how immersive media can be productive spaces for appropriation.

Participants also pointed out that it is pertinent to study how parents view immersive media, similar to Yip's study on parents and caregivers' perspectives on location-based AR games (Sobel et al, 2017). This type of study may help steer parents early on toward best practices for using immersive media with their children. A similar case can be made for teachers, librarians, and other adults who work with children.

4: Applied in practice

While basic research is, undoubtedly, still needed, salon participants focused on applied research across the ecosystem of children's homes, neighborhoods, schools, libraries, museums, and more.

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Such practical applications might concentrate on the learning that is possible if *learning across boundaries* is at the center of investigations with immersive media and children. Along these lines, participants agreed research must seek to understand how all children, and particularly those with certain developmental needs, learn with immersive media in different environments and how this learning connects their different networks/environments. It is also critical to explore how particular design affordances of these media are best applied for learning (e.g., specific modalities: tethered, untethered, degrees of freedom, etc.) within and across what contexts.

Participants were also interested in better understanding how we might design immersive media hardware, software, and content for collaboration, co-creation, and sociality. With these matters of co-engagement, researchers will need to employ relationship-oriented units of analysis (e.g., a dyadic approach). Additionally, how immersive media might help (or not help) children deal with issues of mental health, form and try on new identities, and build empathy all surfaced as fruitful domains of future applied research as well.

In her spark talk, Bailey advocated for (a) studying applications in practice based on longer periods of immersive media exposure and (b) conducting longitudinal studies to understand how any effects of immersive media sustain or change over time. Jennie Ito, Policy Lead at YouTube Kids, recommended carrying out research that compares the effects of immersive media use to those of television, video games, and other media engagement within the ecosystem of children's lives. David Guston, Professor and Director of School for the Future of Innovation in Society at Arizona State University, proposed comparing immersive media experiences with those of the unmediated, physical world for specific types of interventions (e.g., pain distraction) as well.

Exploring priorities for policy, advocacy, and funding

Throughout the salon, participants weighed how other sectors besides research and design may be able to positively influence the direction of immersive media for children. These ideas especially came forth through (a) reflection on the future scenarios participants' developed in the hands-on activities and (b) during the end-of-the-day small group breakout session. In this final session, six small groups of up to 10 participants answered targeted questions about upcoming priorities for different sectors (e.g., what is the role of advocacy or policy groups in shaping a healthy and sustainable ecosystem for immersive media from the start, rather than trying later to correct problems?). Here, we briefly detail the main themes of three sectors not already discussed in the report: policy/regulation, advocacy, and philanthropy/funding. These descriptions do not lay out explicit next steps for these sectors but instead offer areas of further exploration and discourse for these groups.

Policy

Policy became a prominent subject during conversations at the salon due to (a) its potential regulatory power on how children can safely and productively use immersive media and (b) its role in developing research support for new inquiries. Michael Levine, Chief Knowledge Officer at Sesame Workshop, introduced five major topics that are currently relevant to policymakers who are considering the impact of emerging technologies on children and families: safety, family engagement and parental demand/approval, impact and assessment, equity, and cost and scalability.

With these topics in mind, participants debated the role of the Federal Communications Commission (FCC) for immersive media and children. Some participants felt the FCC should issue regulations to formalize the industry-adopted policy that immersive media is not for children under 13 until research deems it safe. Others cited evidence that industry self-regulation can be effective, especially in this case when immersive media as

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a whole are too varied and complex to establish general rules that apply to all systems and content.

Participants also considered the safety benefits of establishing data protection for minors on data collected through immersive media systems, including applying the Children's Online Privacy Protection Act (COPPA) and any updates to this legislation to explicitly consider these new media. Additionally, they thought developing a regulatory framework for advertising within immersive media environments could be an important task for policymakers.

Finally, to support research, participants brainstormed how governmental and nongovernmental policy groups could explore raising money, such as by taxing sales of immersive media systems or otherwise developing an independent funding stream, for important new research on immersive media and children.

Advocacy

Building on the recommendations for policymakers, participants were dedicated to determining the role of advocacy in this domain as well. Advocacy here mainly refers to work professionals are doing with children and media, plus groups and organizations such as Common Sense Media, the Center for Media Justice, and the advocacy division of Consumer Reports. In line with the Entertainment Software Ratings Board, a few participants suggested forming a certifying body or editorial board that is either public or privately funded, to give ratings on immersive media content to help children and families choose appropriate, productive experiences. They proposed these ratings could include things like a stimulus rating, affinity rating, and developmental appropriateness. With these ratings and other information, this body could create new "curation" tools and recommendations for immersive media content for children and families.

Participants expanded on these considerations, offering that such a certifying body or editorial board could also provide crucial parent education (e.g., tutorials, documentation, guidelines, public service announcements, etc.) on age appropriateness, content summaries, rating systems, screen time, and aligning content choice and use with family values and needs. The body could also offer education about immersive media to children, including media literacy programs and explanations on what immersive media are and how these immersive experiences work.

In these ways advocacy groups may be able to help other sectors democratize research for public engagement, perhaps even by disseminating this research to sites where both adults and children are, like YouTube and Twitch.

Funding

Finally, participants requested philanthropists and funders help to raise money for research on immersive media and children, which might also help inform hardware, software, and content development. Participants in the relevant breakout session came up with different options for funding resources and strategies, including social impact investing and financial support from industry developers. However, participants pointed out that developers should not finance research directly, as to not bias the results.

Additionally, participants brought up the critical role of government funding in this domain, from agencies such as the National Science Foundation (NSF) and the National Institutes of Health (NIH). This point is incredibly relevant as a bipartisan group recently introduced the Children and Media Research Advancement (CAMRA) Act to the United States Congress (S. 558, 2019-2020; H. R. 1367, 2019-2020). Not yet passed, the CAMRA Act would dedicate funding for the NIH to conduct research with infants, children, and adolescents on the developmental effects of their exposure to and use of media, including virtual and augmented reality. In line with the approach of this salon, core areas of this research would address media's role in children's cognitive, physical, and socio-emotional development.

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CONCLUSION

Immersive media—augmented, virtual, mixed, and cross reality—are powerful systems, with the potential to have serious ramifications on children's physical, cognitive, and socio-emotional development. Ideally, with thoughtful, consistent reflection and action, immersive media will support learning and development and empower children through equitable access and participation.

Today, we can be proactive and intentional by working to determine what happens when children engage with immersive media, including the specific affordances and limitations of hardware, software, and content that produce specific effects. Even more, we can expand and build on prior research to study immersive media and children with real, commercially available systems before they are used more pervasively by young children.

During the Future of Childhood Salon on Immersive Media and Child Development, participants engaged in purposeful, reflective discussions, debates, and collaborations across a multitude of disciplines and sectors. As a community of designers, developers, researchers, doctors, educators, policymakers, and practitioners, they started conversations about shaping a future for our children that is aspirational but achievable. Still, the considerations for design, research, policy, advocacy, and funding that emerged at the salon merely introduce the beginning of the work that must ensue. Now is the time to individually and collectively ensure that when children engage with immersive media in their near and distant future, their experiences are positive, productive, and safe.

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APPENDICES

Appendix A: Vision papers

To prime participants for the activities planned at the salon, we invited five thought leaders in the field of immersive media and child development, including researchers, developers, and other practitioners, to answer the following question: *What is your vision of immersive media in 10 years and the role these media will play in shaping childhood?* The following vision papers are the five writers' responses.

+ Jeremy Bailenson, Stanford University
+ Lisa Castaneda, foundry10
+ Chris Chin, HTC Vive
+ Michael Rich, The Center on Media & Child Health
+ Jesse Schell, Schell Games

Jeremy Bailenson

Ten years gone, how do VR and AR shape childhood?
I am going to treat VR and AR separately, as I think the psychological processes and effects are very distinct for the two technologies.

Augmented reality
The greatest impact of AR on childhood will surround multitasking. By definition, AR "registers" digital objects in the physical world, and allows users to hear, see, and in 10 years, very likely to smell and somewhat likely to touch them. The game *Pokémon Go* was not a fad, and last month, tens of millions of people played. Preliminary research at the Virtual Human Interaction Lab (we have just begun two separate NSF-funded projects to test how AR changes basic social behavior) indicates that AR changes performance and nonverbal behavior. People change where they look, where they sit, and how they walk in physical room when there are AR objects rendered onto goggles they are wearing. At scale imagine a classroom where each child is seeing different digital objects and digital colleagues in addition to the same set of physical ones. *Common ground*, to quote Herb Clark, will be shattered, in that people will experience different versions of AR reality while physically co-present. One initial finding from our studies shows that social behavior is impacted. On a positive note, we have replicated "social facilitation" effects—college students perform an easy task better when an AR-embodied agent watches them (compared to being alone). On a negative note, an AR event outlasts the experience, and people will avoid sitting in chairs where they previously saw an AR event occur. The benefits to "beaming in" other people will be transformative in terms of uniting people who live far away, removing travel that is considered prohibitive, and ultimately changing the structure of commuting to work and school. But they will change basic patterns of attention and performance in a way that is unprecedented.

Consider one of the most popular video games for the Microsoft Hololens, called *Fragments*. The game uses the simultaneous localization and mapping (SLAM) algorithm to scan one's physical room, and then changes the layout of narrative events of the game so that they "fit" into the room when projected onto the goggles. A murder occurs in one's physical living room, where both characters are perfectly standing on the floor and not intersecting a wall. Similarly, there is a window which is rendered on a wall to look like an actual window in your room. Fast forward 10 years, and imagine watching a scary movie in

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your bedroom. The antagonists will literally be climbing on your bed.

Virtual reality
The biggest concern around VR 10 years from now will be reality blurring. The phenomenon has been studied, though we only have a few studies. Jakki Bailey, who is at the conference, can discuss her pioneering work. In addition, a small-sample study by Kathryn Segovia has shown that young children can confuse VR events from actual ones one week later. Ten years from now, the video and audio fidelity of VR and AR will be close enough to fool the perceptual system. I also suspect scent will be close to perfect, as rendering scent now is pretty easy (clearing the scene is challenging as there is no "refresh" for molecules). For better or worse, we will be able to produce digital experiences 10 years from now that will be, from a perceptual standpoint, perfectly real. So childhood will be defined by a paradox—any child can experience the most fantastical experience imaginable by programmers, but the perceptual system will treat it as a real one. This is a pretty unique moment in human evolution.

Addiction
For both AR and VR, a theme to discuss will be addiction. We have very little empirical data on addiction to VR and AR. Of course there is plenty of work on gaming, but most of that surrounds reward/punishment schedules, not perceptual realism, integration into one's body via tracking, and multi-sensory feedback. To my knowledge there is no study that randomly assigns people to tons of VR/AR use yet, but someone should study this (attendees, please take note). However, most research on "presence" in VR shows that immersive scenes are more engaging and persuasive than non-immersive ones.

Jeremy Bailenson is founding director of Stanford University's Virtual Human Interaction Lab, Thomas More Storke Professor in the Department of Communication, Professor (by courtesy) of Education, Professor (by courtesy) Program in Symbolic Systems, a Senior Fellow at the Woods Institute for the Environment, and a Faculty Leader at Stanford's Center for Longevity. He earned a B.A. cum laude from the University of Michigan in 1994 and a Ph.D. in cognitive psychology from Northwestern University in 1999. He spent four years at the University of California, Santa Barbara as a Postdoctoral Fellow and then as an Assistant Research Professor.

Lisa Castaneda

"I realized that VR could impact learning more than we think. It gives us a real perspective of what actually happens instead of imagining it through a book or a textbook."

Present day middle school student

Foundry10 is a research organization working across many domains, and we have been studying VR and students for several years. Today, students see tremendous potential in VR. In our studies they talk about classrooms of the future where learning is enhanced, where the stylized images of UX interfaces they see in movies today, are everyday experiences. As an educator working with teachers, I believe in the next 10 years we will be able to truly capitalize on these immersive technologies for education if we think carefully now.

A temptation in educational technology is to take new tools and use them in familiar ways, adapting old ideas to new machinery. I am hopeful that in a decade, we will think more broadly. "Incorporating advanced technology" into the curriculum will not be AR "textbooks" or traditional quizzes adjusted for VR. Instead, education may reflect a nuanced understanding of how virtual spaces can restructure spatial learning, enable shifts in perspective, refine skills in simulations, and allow an array of learning interactions that aren't possible now. If we are thoughtful about objectives and content integration, we can engage in ways we could not without those tools, such as being able to witness famous battles and see events first-hand, from multiple perspectives.

The changes are already beginning, and we are seeing them in courses like high school foreign language. In one foundry10 study, we have foreign language teachers using virtual tasks like walking through a city or solving a virtual scenario as the assessment, asking students to use their language skills in real time rather than on paper.

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Ideally, in the future, we will better understand how developmental stages intersect with the virtual world on psychological and cognitive levels so we can design simulations and experiences where cognitive load is decreased, and learners can better assimilate information. This would allow seamless integration of tools into lessons such that they extend our ideas about abstract mathematical concepts, the minutiae of chemistry, complexities of language, and richness of humanities in ways that resonate and are genuine for learners. Rather than going into VR and coming out to do a traditional assessment, the virtual experience itself will be the assessment.

Virtual tools, even today, offer a variety of creative devices that enable students to make amazing things. Designing from their imaginations, they can exploit the strengths of those technologies to build, arrange and rearrange in ways that facilitate an iterative process. Our data show that having students create their own content, as artists or engineers, is something they long to do but often don't quite have the means or interfaces to engage in the ways they believe could one day exist. As designs continue to improve, these creation tools will allow extensions of learning and the chance to prototype easily without breaking learning flow. Educators will continue to develop their own skills—at their own levels and pace— so that they can co-design and craft immersive experiences with students that are meaningful, for both the individual and classroom.

Ten years from now, teachers will also have a much stronger sense of how and when to utilize these tools. They will have data and information about how and when immersive technologies are most effective. Content will be more plentiful across a range of subject areas enabling teachers to think fluidly about how to achieve genuine integration of the content into the classroom.

To make these ideas reality, we must think critically about the role of XR within educational settings today. We need to objectively assess the strengths and challenges that these technologies bring. Instead of just hoping and assuming the tools will help learners, we, as educators, need to gather data, utilize student and teacher feedback, and actively work with developers to take what we know about learning and what they know about virtual spaces to truly enhance education.

Lisa Castaneda, M.Ed., is a Co-Founder and the CEO of foundry10, a philanthropic educational research organization, which was created to expand the ways in which people think about learning. Through applied and experimental studies done in collaboration with educators, researchers, and community organizations, our work bridges the gap between research and practice, and provides direct, actionable change in the communities in which we work and beyond.

Chris Chin

From *Ready Player One* to *The Matrix*, authors, futurists, and Hollywood have painted a picture of how VR could evolve in our lives—a future VR-driven world predicated on the usual suspects that we already encounter today: corporate greed, technology, and ultimately control of free will. In contrast, I see a decidedly brighter vision of the future of VR, one in which education, equity, and empathy play an increasingly large role in shaping our future and that of our children.

For reference, we need only look at the rise of mobile to understand how quickly technology can evolve to shape our lives. The early days of smartphones yielded basic calendaring, to-do lists, and web access, all revolutionary at the time. The most popular app in 2007, the iPhone's first year, was a koi fish pond mini-game. Today, phones and tablets are ubiquitous and almost essential to daily life. In education, textbooks, assignments, and multimedia lessons are increasingly distributed and consumed through these devices, which have become tremendous resources for learning and information.

While VR has been around for decades, the first consumer-level high-end VR devices that launched in 2016 are analogous to the initial cellular phone "bricks" that predate the state-of-the-art devices we have today. Today's VR, powered by a PC, is nonetheless amazing. With roomscale VR, anyone with an HTC Vive Pro can walk around and explore a 33'x33' virtual space in HD resolution without being tethered to the

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PC, already a significant improvement from two-and-a-half years ago. Hundreds of educational VR experiences exist where students can learn about the human heart in full immersive 3D, navigate a Lunar lander 50 years after the first moon landing, or discover the secrets of the ancient pyramids.

While mobile has afforded tremendous change, VR has the capacity to go even further in impacting education and as a tool for equity. We know that experiential learning in VR can decrease a student's cognitive load and help improve learning outcomes. We know from Edgar Dale's Cone of Experience that learning by doing is much more effective for memory retention than reading, watching, or listening. VR's ability to simulate any environment and have the student learn by doing effectively levels the playing field for all learners, whether they be visual, auditory, reading/writing, or kinesthetic.

This bodes well for the future as the field of artificial intelligence rapidly emerges. When learners can process a lesson in the format in which they learn best, and that's coupled with adaptive learning AI and built-in assessment feedback loops, truly personalized learning can be achieved and education parity starts to become a reality.

Thus, the potential for equity in education becomes closer to reality in 10 years, along with increased development of empathy in our students towards the plight of others. Already, VR is helping students break stigmas around race and homelessness. In the future, we will see VR foster empathy for the diversity of circumstances we individually experience, including gender, background, ethnicity, religion, or physical or cognitive disability.

Finally, from a hardware standpoint, we will see device form factors become smaller, lighter, and more "accessorized." With the advent of 5G mobile networks, we will "cut the cord" entirely and our mobile VR devices will take on the form of visors/glasses that can be comfortably worn all the time, with pass-thru ability for an augmented/mixed reality experience. Eye tracking and new brain-computing interface (BCI) sensors will form the basis for new ways of interaction and control with our virtual environments. And haptics embedded in our clothes and gloves will provide physical feedback and a level of immersion far more engrossing and realistic than ever before.

I look forward to this future, with better ways of learning for our students, more opportunities for equity in education, and a pathway towards a more empathetic world.

Chris Chin is Executive Director of VR Content at HTC Vive. He has 20+ years leading product, content, and business operations in gaming, mobile, and ed tech. He is passionate about the potential of VR in education and currently heads up education content and strategic initiatives at HTC Vive. @chrisforevr

Michael Rich

Virtual reality (VR) is an oxymoron. And it functions as one, presenting both potential and perils for childhood. The tech industry is betting big on VR and its close relative, augmented reality (AR), predicting that by 2025, VR/AR will command $11.6 billion in video gaming, $3.2 billion in screen entertainment, and $7 million in education (likely an underestimation). By 2022, it is estimated that >100 million VR/AR headsets or glasses will be in use.

What does this mean for children? Can VR/AR expand the world of childhood by providing near-infinite information and (virtual) experience? Or will it implode human society, with individuals retreating into unique, curated experiences in their own heads? Will we develop into what Francis Coppola predicted in a conversation with Akira Kurosawa in 1979, a loosely connected mesh of disembodied minds, each telling our own stories, writing our own music, and making our own movies? Any and all of these are possible.

Play is the work of childhood and toys and games are where much VR/AR innovation is happening. But we cannot make the glib assumption that kids will love VR/AR toys, games, and education long enough to benefit from it. If VR/AR does not provide a sustaining interest, children will move

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to the next bright, shiny thing once the novelty wears off. (Remember *Pokémon Go*?) Stimulus provided by VR requires significant cognitive processing to synthesize and integrate, with a particularly heavy load on the executive functions of the prefrontal cortex. "Brain overload," especially acute in children whose prefrontal cortices will not complete development until their mid- to late 20s, is the reason why 3D movies have (repeatedly) been hugely popular, then faded almost as rapidly. AR, especially when built into glasses, will need to solve the "creepy" sense of users behaving like zombies because they are rapidly toggling between virtual and physical worlds. (Remember Google Glass?)

Developers speak glowingly of VR/AR creating immersive, three-dimensional experiences at the computer-human interface, improving digital literacy, communication, collaboration, creativity, and problem-solving. The goal is to take advantage of children's engagement and facility with interactive media to reinforce enjoyment and confidence in learning, building the "twenty-first century skills" necessary to move beyond receiving information to synthesizing, integrating, and transforming it. However, many of these theoretical potentials have yet to be realized, especially for children whose brains have not yet developed the complexity necessary to take advantage of them. This raises the concern that children's brains, developing in a VR/AR environment where anything is possible and pre-processed information and experiences are delivered on demand, will be irreversibly altered toward the entitled, incurious, and passive.

In designing VR/AR devices and applications for children, it is critical to keep in mind the active and inquisitive nature of children, the key developmental tasks of each age and stage, and the profound influence of environmental stimuli and challenges on their physical, mental, and social development and health. To be most effective, VR/AR must be designed to respect and promote a rich and diverse menu of childhood experience rather than replace them with attenuated analogs. Children are exquisite sensors of the physical, social, and emotional. Regardless of the visual resolution and audio fidelity, VR/AR cannot recreate the feel of an orchard breeze, the smell of fertile soil, or the crisp, juicy crunch of an apple fresh off the tree. Artificial intelligence cannot approach your mother's loving smile, the warmth of her lap, or the safety of her embrace. Used mindfully, in focused and directed ways that optimize its capabilities as a tool, VR/AR can be designed to springboard children's engagement with the physical world with imagination and playfulness, to connect with others in deep and authentic ways, and to approach problems with a critical mind, a creative spirit, and an empathetic heart.

Michael Rich is the Founder and Director of the Center on Media and Child Health, an academic center of excellence at Boston Children's Hospital dedicated to investigating, translating, and innovating with media to optimize the physical, mental, academic and socio-emotional health and development of children and adolescents. Dr. Rich advises pediatricians, educators and parents on how to optimize child development in the Digital Age at askthemediatrician.org.

Jesse Schell

While many people think of virtual reality as a technology for the eyes, in truth VR is a technology that allows us to interact with computer generated worlds using our bodies. By creating the illusion of presence, VR lets you feels as if you are truly in a place that you can reach out and touch. This creates countless opportunities for powerful new experiences of exploration, discovery, and play. Presently, the high cost and fragility of VR systems has made it a system strictly in the domain of adults. Over the next 10 years, we will see this change radically because of a secret that no one wants to admit: VR is a medium for children. No one likes to say this, because of fears about how long term use of VR and AR might affect children's developing eyes and minds. These are valid concerns, and they are same ones we saw at the inception of television. And, like with television, the technology will be so appealing to children it will be difficult to keep them away from it, and gradually safety concerns will subside as we will acclimate to virtual and augmented reality being part of children's lives.

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Why do I say that VR and AR are media for children? For two reasons. First, the primary feature of these mediums is that you interact with your body. These are experiences that encourage standing, walking, throwing, touching, grabbing, holding, stretching, ducking, and crawling. Adults are shy about interacting with their bodies. They prefer to sit and watch, or point and click. For children, exploring the world is a full-body experience, which lines up perfectly with the strengths of VR and AR.

The second reason is because one of the most powerful experiences that VR and AR are able to provide is that of giving the user an imaginary friend. As these technologies evolve over the coming decade, another technology will be advancing and merging with them: artificial intelligence. The time is not far away when every child given the opportunity will be able to don a special pair of glasses that lets their imaginary friend become a real friend, someone they can see, touch, and play with. This friend will be a tireless playmate, always there and ready to play whatever games, indoors or out, that a child wants to play. And while this sounds like it could be an antisocial experience, it won't be, because other children will have them too, and the glasses will let you see not only your imaginary friend, but the imaginary friends of your real world playmates. But why will parents allow these strange virtual friends into their homes and into their children's lives? Because these new friends will be so much more than playmates. Connected to the internet, they will have a world of information at their fingertips, and like a great teacher or parent, the imaginary friends will seamlessly weave valuable teaching moments into the play experience, and what parent will be able to resist a tireless tutor and playmate that their child loves?

It is easy to be afraid of this future, easy to condemn and warn against it. But perhaps the most useful thing we can do is to plan for it. VR and AR are not just gadgets—they will be the eyes of the next generation. We should all work together to give them the best eyes humanity has ever known.

Jesse Schell is the CEO of Schell Games, a team of one hundred people who strive to make the world's greatest educational and entertainment games, including HoloLAB Champions, the Daniel Tiger's Neighborhood games, and Happy Atoms. Schell Games also creates pure entertainment content, such as the award-winning VR game, I Expect You To Die. Jesse also serves as Distinguished Professor of the Practice of Entertainment Technology at Carnegie Mellon University. Jesse is also the author of the award-winning book The Art of Game Design: A Book of Lenses.

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Appendix B: Salon agenda

DAY 1: WEDNESDAY, NOVEMBER 7, 2018

8:30 AM Registration and breakfast

9:00 AM Welcome, goals, and introduction
+ David Guston, Arizona State University
+ Steve Youngwood, Sesame Workshop
+ Lori Takeuchi, Joan Ganz Cooney Center
+ David Kleeman, Dubit

9:45 AM Research presentations on virtual, augmented, and mixed reality use
+ Cindy Ball, Oculus
+ Jakki Bailey, University of Texas at Austin
+ Jason Yip, University of Washington
+ Mina Johnson-Glenberg, Arizona State University
+ Robb Lindgren, University of Illinois at Urbana-Champaign

10:45 AM Case Study: Doc McStuffins: Doctor for a day - VR experience
+ Vicki Ariyasu, Disney Junior, & Mark Bartscher, Disney ABC Television Group; moderated by Jordan Shapiro, Joan Ganz Cooney Center

11:15 AM Break

11:45 AM Current platforms and projections forward
+ Dan Ayoub, Microsoft
+ Alan Gershenfeld, E-Line Media

12:15 PM Breakout session primer; breakout session 1: Meet your Child

1:00 PM Lunch and demos

2:00 PM Spark talk: Contextual narrative as an information architecture for immersive learning
+ Curtis Wong, Trinity College Dublin (formerly Microsoft Research)

2:15 PM Breakout session 2: Worldbuilding

2:45 PM Spark talks: Imagining futures
+ Susanna Pollack, Games for Change
+ Michael Rich, Center on Media and Child Health
+ Justine Cassell, Carnegie Mellon University

3:15 PM Breakout session 3: A day in the life

4:00 PM Break & demo

4:30 PM Breakout session 4: Reflections and implications

5:10 PM Whole group: Share out designs

5:50 PM Whole group: Wrap up and what to expect tomorrow

6:00-7:30 PM Reception and poster viewing

DAY 2: THURSDAY, NOVEMBER 8, 2018

8:30 AM Breakfast and poster viewing

9:00 AM Spark talk: Avoiding past mistakes with children's media
+ David Kleeman, Dubit

9:15 AM Whole group: What more do we need to know? Setting a research agenda
+ Discussion led by Ellen Wartella, Northwestern University

9:45 AM Breakout session 5: Best practices

10:20 AM Whole group: Best practices

10:45 AM Break

11:00 AM Breakout session 6: Action steps by sector

11:35 AM Next steps and wrap-up

12:00 PM Lunch and adjourn

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Appendix C: Speaker bios

Panel 1: Research presentations on virtual, augmented, and mixed reality and young children

Jakki Bailey, Assistant Professor at the University of Texas at Austin, specializes in immersive media, and its influence on cognition, behavior, and learning. She researches the psychological implications of VR on child development, and is currently studying VR's influence on children's cognitive skills and social responses.

Cindy Ball is the Program Manager of Oculus Education at Oculus. Passionate about technology's positive impact on education, she has 20+ years in animation, computer graphics, game development, AR/VR experiences, research, and learning platforms. She currently leads Oculus's Education programs in research, schools and libraries.

Mina Johnson-Glenberg is a Research Professor at Arizona State University and the Founder/President of Embodied Games. Dr. Johnson-Glenberg's team creates, researches, and distributes innovative XR content for 4th grade through life-long learning. Her specialties include efficacious content for embodied learning and VR health applications.

Robb Lindgren is an Associate Professor of Curriculum & Instruction and Educational Psychology at the University of Illinois at Urbana-Champaign. He is a researcher/designer who creates embodied and immersive experiences for STEM learning. He seeks to build powerful interactive simulations with AR/VR/MR tech that forge meaningful connections between body movement/actions and key concepts. He's happiest when running.

Jason Yip is an assistant professor at The Information School, and adjunct assistant professor in Human Centered Design & Engineering at the University of Washington. His research examines how technologies can support parents and children learning together. Follow @jasoncyip

Panel 2: Current platforms and projections forward

Dan Ayoub is General Manager for Education at Microsoft. He oversees the development and execution of products and strategy aimed at using Mixed Reality technology to improve learning outcomes for students of all ages around the world, and is also driving initiatives related to STEM, creativity, and AI. Dan has more than 20 years of development experience, and is passionate about the power and importance of education and ensuring that technology remains accessible to every human being on the planet. Based out of Seattle, Dan leads a team of passionate developers and educators working to shape the future of educational technology.

Alan Gershenfeld is President/Co-Founder of E-Line Media, a publisher of digital entertainment that engages and empowers and Co-Founder of Experimental Design, a world building agency. Previously Alan was Head of Activision Studios, and Chairman of Games for Change.

Case Study: Doc McStuffins: Doctor for a day - VR experience

Vicki Ariyasu is Vice President of Disney Junior's Educational Resource Group, a team responsible for the integration of early childhood educational content, prosocial engagement, and inclusion across intellectual properties and brand extensions.

Mark Bartscher is Senior Manager of Product Strategy at Disney Junior, Disney ABC Television Group. He is a kids entertainment and media strategist with over 15 years experience developing innovative kids content and products for new media. Working at the cross-section of technology, kids, and storytelling, Mark's focus is on creating new ways for kids to engage with the tv shows and characters they love.

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Jordan Shapiro, PhD, is senior fellow for the Joan Ganz Cooney Center at Sesame Workshop, Nonresident Fellow in Global Economy and Development at the Brookings Institution, and Assistant Professor at Temple University in Intellectual Heritage. He is the author of The New Childhood. @jordosh

Spark talk 1: The past and future of immersive realities

Curtis Wong retired from a 35-year career at the intersection of media, arts, science and technology, working with top Leonardo da Vinci scholars around the world to discover new information about Leonardo da Vinci's work as a scientist. His work at Microsoft to create the WorldWide Telescope empowered millions of people to explore and understand the Universe. Curtis worked with PBS/CPB for 25 years serving on advisory boards as well as producing PBS programming too.

Spark talk 2: Imagining futures

Michael Rich, MD, MPH, is the Founder and Director of the Center on Media and Child Health (@cmch_boston) at Boston Children's Hospital, Associate Professor at Harvard Medical School & Harvard T.H. Chan School of Public Health, pediatrician, researcher, father, and media aficionado.

Susanna Pollack is the President of Games for Change, the leading global advocate for the power of games and immersive media as drivers of social impact. Programs include the Games for Change Festival, XR for Change Summit, the Games for Learning Summit and G4C Student Challenge.

Justine Cassell is Associate Dean of Technology Strategy and Impact in the School of Computer Science at Carnegie Mellon University, and Director Emerita of CMU's Human Computer Interaction Institute. Justine Cassell travels from discipline to discipline to find the best tools to better understand children and to more effectively bring their voices to the table.

Spark talk 3: Avoiding past mistakes with children's media

David Kleeman, an analyst, strategist, writer, and speaker for 30+years, has sought sustainable solutions for quality children's media. He now speaks/writes as the Senior Vice President of Global Trends for kids research consultancy/ digital studio @Dubit. Home is an aisle seat near the front. Follow @davidkleeman.

Hosts and moderators

Ed Finn builds more inclusive, inviting, and imaginative futures. He is the founding director of the Center for Science and the Imagination at Arizona State University. Some of his books include What Algorithms Want; new Frankenstein for STEM readers; and Hieroglyph. @zonal

David H. Guston is professor and director of the School for the Future of Innovation in Society at Arizona State University, where he is also co-director of the Consortium for Science, Policy and Outcomes. He is widely published and cited on R&D policy, technology assessment, public participation in science and technology, and the politics of science policy.

Lori Takeuchi is Deputy Director and Head of Research at the Joan Ganz Cooney Center. Prior to holding this position, Lori was the Acting Executive Director of the Center. Before that, she served as research director, leading several of the Center's distinguishing initiatives, including the fellows program, Print Books vs. E-books, The New Coviewing, Aprendiendo Juntos, the Families and Media Project, and the Families Learning Across Boundaries initiative.

Ellen Wartella is Sheikh Hamad bin Khalifa Al-Thani Professor of Communication and Director of the Center on Media and Human Development at Northwestern University. She studies the effects of media and technology on children's health and development.

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Ruth Wylie is the assistant director of the Center for Science and the Imagination and an assistant research professor in the Mary Lou Fulton Teachers College at Arizona State University. Ruth concentrates on interdisciplinary, translational research that leverages knowledge and insights from theory and lab studies to answer real-world problems.

Steve Youngwood is President of Media & Education and Chief Operating Officer of Sesame Workshop. Steve oversees global distribution, sponsorship, product licensing, themed entertainment, and education efforts. Since joining the Workshop in 2015, Steve has spearheaded its growth, including new partnerships with HBO, YouTube, McGraw-Hill, SeaWorld and IBM Watson, new TV productions around the world, and expansion in China, Latin America, the UAE, and beyond.

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Appendix D: List of participants

Vicki Ariyasu
Vice President, Educational Resource Group
Disney Junior Education & Social Responsibility,
Disney Channels Worldwide Diversity & Inclusion

Dan Ayoub
General Manager–Education
Microsoft

Jakki Bailey
Assistant Professor
University of Texas at Austin

Cindy Ball
Program Manager, Oculus Education
Oculus

Sasha Barab
Executive Director, Professor
Center for Games and Impact,
School for the Future of Innovation in Society
Mary Lou Fulton Teachers College,
Arizona State University

Mark Bartscher
Senior Manager, Product Strategy
Disney Junior, Disney ABC Television Group

Chantal Bowen
Executive Director
Youth Media Alliance

Jennifer Burkitt
Vice President Digital
Pipeline Studios

Justine Cassell
Associate Dean, Technology Strategy and Impact
School of Computer Science,
Carnegie Mellon University

Britte Haugan Cheng
Principal
Menlo Education Research

Chris Chin
Executive Director of VR Content
HTC Vive

Dimitri Christakis
Director
Center for Child Health, Behavior, and
Development, Seattle Children's Hospital

Scott Clark
Director
Hasbro, Inc.

Chris Dede
Timothy E. Wirth Professor in Learning Technologies
Harvard University

Sara DeWitt
Vice President, PBS Kids Digital
PBS Kids

Christine Elgersma
Senior Editor, Parent Education
Common Sense Media

Ed Finn
Director
Center for Science and the Imagination,
Arizona State University

Ellen Lenihan Flaherty
Senior Learning Architect
Unity Technologies

Alan Gershenfeld
Co-Founder and President
E-Line Media

Akimi Gibson
Vice President & Education Publisher
Sesame Workshop

David H. Guston
Professor & Director
School for the Future of Innovation in Society,
Arizona State University

James Hairston
Head of Policy
Oculus

Geoconda Idrovo
Project Manager, Corporate Social Responsibility
Verizon Foundation

Jennie Ito
Policy Lead, YouTube Kids
YouTube

Nancy Jennings
Associate Professor
University of Cincinnati

Catherine Jhee
Director, Web and Strategic Communications
Joan Ganz Cooney Center

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Mina C. Johnson-Glenberg
Research Professor
Arizona State University and Embodied Games

Lauren Withycombe Keeler
Assistant Research Professor
School for the Future of Innovation in Society,
Arizona State University

David Kleeman
Senior Vice President, Global Trends
Dubit

Michael H. Levine
Chief Knowledge Officer
Sesame Workshop

Debra Lieberman
Director, Center for Digital Games Research
University of California Santa Barbara

Robb Lindgren
Associate Professor
University of Illinois at Urbana-Champaign

Miles Ludwig
Vice President, Digital Production
Sesame Workshop

Stacey Matthias
Board Member
Bridge Multimedia

Josh Meibos
2018 Arizona Teacher of the Year
Arizona Educational Foundation

Punya Mishra
Associate Dean of Scholarship and Innovation
Mary Lou Fulton Teachers College

Brooke Morrill
Director of Education
Schell Games

Susanna Pollack
President
Games for Change

Reirui Ri
Google Play, Policy Expert
Google

Michael Rich
The Mediatrician
Center on Media and Child Health,
Boston Children's Hospital

Vicky Rideout
President
VJR Consulting

Cynthia Selin
Associate Professor
School for the Future of Innovation in Society,
Arizona State University

Jordan Shapiro
Senior Fellow
Joan Ganz Cooney Center

Kiley Sobel
Research Scientist
Joan Ganz Cooney Center

Tom Swanson
Head of Organizational Growth and Outreach
foundry10

Lori Takeuchi
Deputy Director and Head of Research
Joan Ganz Cooney Center

Richard Thomas
Vice President Architecture - Executive Director
SHP / 9 Billion Schools Institute

Claudia Wallis
Columnist/Journalist
Scientific American

Ellen Wartella
Al-Thani Professor of Communication
Northwestern University

Curtis Wong
Retired Educational Media Producer
Project C2

Ruth Wylie
Assistant Director
Center for Science and the Imagination
Arizona State University

Jason Yip
Assistant Professor
University of Washington

Steve Youngwood
President of Media & Education and Chief
Operating Officer
Sesame Workshop

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The Joan Ganz Cooney Center at Sesame Workshop

The Joan Ganz Cooney Center at Sesame Workshop investigates the potential of digital media to help children learn and collaborates with educators, media producers, policymakers, and investors to put this research into action. An independent nonprofit organization, the Center addresses issues of digital equity and aims to strengthen connections between formal and informal learning environments.

the Joan Ganz Cooney Center
at Sesame Workshop
advancing children's learning in the digital age

Center for Science and the Imagination, Arizona State University

Arizona State University's Center for Science and the Imagination brings writers, artists and other creative thinkers into collaboration with scientists, engineers and technologists to reignite humanity's grand ambitions for innovation and discovery. The center serves as a network hub for audacious moonshot ideas and a cultural engine for thoughtful optimism. We provide a space for productive collaboration between the humanities and the sciences, bring human narratives to scientific questions, and explore the full social implications of cutting-edge research.

ASU Center for Science and the Imagination
Arizona State University

School for the Future of Innovation in Society, Arizona State University

The School for the Future of Innovation in Society (SFIS) is a transdisciplinary unit at the vanguard of ASU's commitment to linking innovation to public value. SFIS pursues a vision of responsible innovation that anticipates challenges and opportunities, integrates diverse knowledge and perspectives, and engages broad audiences. By examining the ways we translate imagination into innovation—and how we blend technical and social concerns along the way— we will build a future for everyone.

ASU SCHOOL FOR THE FUTURE of Innovation in Society
ARIZONA STATE UNIVERSITY

Dubit

Dubit is a worldwide research and strategy consultancy and digital studio, focused on children and youth. For 20 years, it has created popular, engaging, beneficial content and products, rooted in its research team's insights into kids' behaviors and their digital lives. Dubit's studio has created works for top brands, including Lego, PBS Kids, Mattel and others. Its research arm runs a twice-yearly global Trends survey, designs bespoke research for clients, and conducts thought-leadership studies into themes like kids and virtual reality and preschoolers and tablet use. Dubit is based in Leeds, England, with offices in the US and Australia.

dubit

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