Exploring Parent Use of Early STEM Media to Inform Design for Children

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ABSTRACT

This paper explores how parents identify and use science and math media to engage their preschool children in informal science and math learning. Through an interview study, we examine parental beliefs about media's role in their preschool-aged children's science and math learning. We report how parents approach finding and incorporating different forms of media into their child's informal learning and conclude with a discussion of design implications for creating educational media for preschool-aged children.

CCS CONCEPTS

K.3.1 [Computer and Education]: Computer Uses in Education - Collaborative Learning. H.5.2 [Information Interfaces and Presentation]: User Interfaces - User-Centered Design.

KEYWORDS

science; mathematics; early childhood; preschool; education; parents; design; YouTube

1 Introduction

Early math and science learning may lay the foundation for science, technology, engineering, and math (STEM) achievement in elementary school and beyond. Multiple studies show that math skills learned during the preschool years are related to children's academic success in math

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during elementary and high school [29]. Importantly, preschool children can also learn STEM concepts from media like apps, television, online video, and computer games [16]. Parents play a critical role as their children's first teacher including the introduction of science- and math-related activities [15], yet there is a lacuna of research that documents how parents utilize media as a tool to support preschool-aged children's informal science and math learning. Given the omnipresence of media in children's lives [24] and that learning STEM skills is imperative for students to meet the needs of the predicted future workforce [9], it is important to understand the nuanced ways that parents use media for their children's informal STEM learning. An understanding of how parents and their children use STEM media for learning can permit content creators to design media and learning opportunities that better fit the needs of parent and child users.

Research has yet to explore how parents naturally use media as an educational STEM tool. To begin exploring this topic, we conducted semi-structured interviews to identify the nuance within parents' conceptual understandings of how media can be incorporated into early informal learning of math and science, two foundational pillars of STEM. Using a grounded theory approach, we sought to create a general explanation and interpretation, grounded in the experiences of those we interviewed, of how parents use and conceptualize different types of media (i.e., television shows, mobile apps and games, internet resources) as tools to support their child's learning. Our explanation includes whether parents identify and use media differently for science and math as well as if they express concerns around using science and math media with their preschool children.

With this work, we make two main contributions to the IDC community. First, human-computer interaction (HCI) exerts more focus on the design aspects of media elements and interfaces rather than the context of media consumption. While this is important work, it must be situated within the

context of how families approach, identify, and incorporate media and technology into their children's lives. Second, this work expands the IDC community's understanding of how parents situate media and technology within their child's early science and math learning environment, which can be useful to those developing such content for children. By identifying areas where parents may need help supporting their child's early learning, we highlight opportunities for media creators to design products that align with parents' needs, as well as opportunities for future work within the IDC community that expands our understanding of parents' media experiences.

2 Related Work

2.1 How Parents Support Early STEM Learning

While children will formally experience science and math learning when they enter the classroom, parents play a critical role in facilitating their child's first learning experiences [5]. Parents influence their child's early STEM experiences by introducing them to science- and math-related activities during their early years [15]. For example, parental participation in and encouragement of math or science activities strongly predicts children's participation in outside-of-school science, math, and computer activities in elementary school [27].

Media, such as apps, television, and online sites, may be important tools for helping parents expose their children to science and math content [16] because such media are often engaging and accessible to many families (e.g., public television). Educational content depicted in children's media can open the door to at-home learning in similar subject areas [4]. Notably, media can also be leveraged as a tool to help parents who feel anxious about teaching their child STEM concepts. One study found that parents who were especially anxious about supporting early math learning could promote their own skills as an educator by playing a math-based app with their child [6]. Additionally, parents are often in control of selecting which apps are installed on devices their children use [7], serving as a gatekeeper for what content children access.

2.2 Media and Early STEM Learning

Parents recognize that media can be educational, yet we know little about how parents identify STEM in media and use it for their preschool-aged child's informal learning. A better understanding of how parents identify STEM in media is important because educational media has been shown to be effective in teaching science and math concepts to young children [16]. For example, viewing *Sesame Street* at age 5 was predictive of higher science grades in high school [3]. Evaluative studies have found that classroom exposure to PBS KIDS shows like *Peep and the Big Wide World* and *Sid the Science Kid* encouraged outside-of-school science engagement

for preschoolers [20], and regular home consumption of *Peg + Cat* led to better mastery of certain math skills [19]. Considering interactive platforms, research shows that when preschool-aged children engaged with an app-based math curriculum in their preschool classroom, they learned foundational math skills, like subitizing and equipartitioning [18]. Preschool-aged children can also learn measuring with non-standard units, another foundational math skill, by watching a video or interacting with an app on a touchscreen device [2]. In sum, there is a vast array of evidence showing that preschool-aged children can learn science and math concepts from media. Given that parents are important for encouraging their child's STEM learning before they enter formal schooling, it is necessary to understand how parents identify STEM learning opportunities in media and use such media as a tool to promote their child's early STEM learning.

3 Method

We conducted 12 semi-structured interviews investigating how parents engage their children in informal math and science learning. The nature of semi-structured interviews allowed us to further probe for additional details if parents' descriptions of media's role for their children emerged in unexpected ways from how researchers typically account for media use. Prior to collecting data, our interview guide was refined through iteration after we conducted three pilot interviews, wherein we confirmed that we were asking the right types of questions to elicit information about the desired process (interview guide available upon request). Between April – June 2017, we interviewed parents of children between the ages of 3 and 5.5 years old. Participants were recruited via the research center's database. Prior to the interview, participants were informed about the study's topic areas as we wanted to gather deep, rich details [28] about the everyday experiences of how parents did or did not incorporate informal science and math media and activities into their child's lives. All of the participants resided near a large metropolitan U.S. city, were women, aged between 31 and 47 years old, and most were married ($n=9$). The sample mostly identified as White ($n=8$), followed by Black or African American ($n=2$), Asian ($n=1$), and Hispanic, Latino, or Spanish origin ($n=1$). The sample was economically diverse with annual household income levels ranging from \$20,000 - \$175,000. All of our participants were highly educated: one possessed an Associate's degree and some held a Bachelor's degree ($n=5$), a Master's degree ($n=4$), or a professional or doctoral degree ($n=2$). Five of the participants were stay-at-home parents, six worked as paid employees, and one was self-employed. We utilized a small, purposeful sample, as is typical in grounded theory work [17].

Each in-person interview included the lead researcher, lasted between 30 minutes and 1 hour, and occurred in a private space in either a university laboratory or participant's workplace. After the interview, participants completed a demographics questionnaire. All interviews were audio recorded and transcribed. This research study was evaluated

and approved by Northwestern University's Institutional Review Board.

3.1 Analysis and Coding

The data analysis followed a grounded theory approach [28]. Throughout the data collection period, two researchers and one research assistant frequently met to identify emergent concepts and to iteratively refine the interview protocol to capture topic areas that needed additional probing. This constant comparison helped the researchers understand how and if parents use media to supplement learning and allowed the researchers to seek new information that had not already been uncovered in previous interviews. Based on the depth of the data provided by the 12 parents and the dearth of new information emerging from our later interviews, our interviews reached saturation with 12 parents, meaning parents were no longer providing further insight [8] and no identified related topic areas remained unquestioned [28].

Three trained researchers worked to identify themes that existed within the data through open coding. The researchers iterated upon a codebook through multiple meetings as they reengaged with the data through inductive coding. Ultimately, a set of 46 main codes, such as “media as educational” (e.g., “nature shows are helpful because you get to learn something without having to travel somewhere”), and 21 subcodes, such as “media as a source of information” (e.g., “TV is another good way because it can provide information that she wouldn't have known otherwise”) were generated by the three researchers to form our codebook (available upon request). Each transcript was reviewed and independently coded by two researchers who then met to compare and reach consensus before moving forward with coding additional transcripts. Once all transcripts were coded, the codes were conceptually linked into thematic groups, such as “Internet science” (e.g., parents identifying science media that existed online), using axial coding [28], wherein the researchers grouped codes together based upon how they connected and co-occurred within the identified themes.

Throughout the analysis process, the researchers engaged in memo writing to facilitate the conversation with the data and to identify how the themes and codes interacted with or were separate from each other.

4 Results

While myriad themes emerged from the rich data collected during the interviews, the main findings describe how families report identifying and using media to engage their preschool-aged child in informal math and science learning and reasons for avoiding certain media. Additional data about math and science activities were used to inform the development of a parent survey and are beyond the scope of this article.

4.1 Using Media to Reinforce Learning

Parents approached using media as a support tool for science and math learning in different ways. The majority of parents

believed media could incorporate educational aspects, but most parents thought media served better as a reinforcement of already familiar educational concepts rather than a means of introducing their children to new material. Parent 4 said,

“I think the fact that [math learning] is supported by something else (media) helps a lot so it's not like I'm sitting her in front of the TV and she has never seen or heard [the math concept] before and she's trying to learn it from there. I think it's a good supportive tool for the things that she knows. [...] She's not necessarily learning from [media], but it's reinforcing the things that she knows.”

Similarly, when asked if she thought her child was learning science and math concepts through media exposure, Parent 12 said, “I think she's learning all of this through media, or being exposed to it through media, but you definitely need some other components to help make it stick.”

Another parent (Parent 1) stressed her belief that media alone cannot educate children within this age range:

“I don't think that [media] would be a replacement necessarily for what we do or for school, but I think it's sort of an avenue of interest for [my child] so when those concepts are introduced, [media] is a supplemental way to learn these things.”

With this, Parent 1 implied that media can complement concepts that are already being learned by her child and that media might be an interesting way to hold her child's attention as they build upon their learning.

4.2 Differences between Identifying Math and Science Media

Math media was easier for parents to identify and recall in comparison to science media. Parent 7 said:

“I feel like [science] is a little bit... not as clear cut. [...] I feel like that's a lot less formal than 'Let's learn how to count to 10' [in math media]. Where, it's maybe exposure to science and a less rigid lesson.”

Throughout the interviews, every parent was able to conjure a television show or app that they believed featured opportunities for math learning. For television shows, six parents mentioned *Sesame Street*, three parents mentioned *Team Umizoomi*, two parents mentioned *Odd Squad*, and two parents mentioned *Peg + Cat* as being related to math learning. The following shows were each mentioned by only one parent: *Baby Einstein*, *Blaze and the Monster Machines*, *Blue's Clues*, *Curious George*, *Dinosaur Train*, “DIY (do-it-yourself) building shows”, *Dora the Explorer*, *Mickey Mouse Club House*, *Paw Patrol*, and *PJ Masks*. There were no overlapping apps that multiple parents thought incorporated math learning; the following apps or show-related apps were each mentioned by only one parent: *ABCmouse*, *Animal Math Games*, *Blaze and the Monster Machines*, *Color Switch*, *Curious George*, *Dora the Explorer*, *Dots*, *Jigsaw Puzzle*, *Grandma's*

Kitchen, Grandpa's Workshop, Mike the Knight, Monster Math, Paw Patrol, Super Why!, and 123 Ninja.

Some parents, like Parent 8, did not place value in seeking science opportunities for her child via interactive media in comparison to other subject areas,

"If someone were to recommend an app that they said was really good [for science], I would be eager to try it, but I haven't gone scouring the app store for something that's going to teach science. I have focused more on letters, language, and math."

Other parents expressed frustrations at their failed attempts to easily find some science media for their children. Parent 4, who mentioned deliberately seeking science apps, seemed disappointed in the dearth of apps that were devoted to science exploration: "I don't see a lot of apps specifically for science. They'll use science to teach something else, so like science to teach letters or math or counting, but not science for science at that [preschool] age."

While some parents could not think of any media that they believed incorporated science learning, other parents provided examples of television shows that they believed featured science concepts. Three parents mentioned *Dinosaur Train*, and *Doc McStuffins*, *Nature Cat*, *Odd Squad*, *Sid the Science Kid*, and *Wild Kratts* were each mentioned by two parents. The following shows were each mentioned by only one parent: "animal shows", *Baby Einstein*, *Bill Nye the Science Guy*, *Blue's Clues*, *Daniel Tiger's Neighborhood*, *Dora the Explorer*, *Dot*, *The Magic School Bus*, *Master Chef*, *Miles from Tomorrowland*, *SciGirls*, and *Shimmer and Shine*. As with math-related apps, there were no app examples that multiple parents believed were related to science. Each of the following apps were mentioned by only one parent: *ABCmouse*, *Fishing with Grandpa*, "geocaching", *Grandma's Garden*, *Grandma Loves Bugs*, *Scratchjr*, and "weather apps" (for doppler information).

Despite the range of apps and television shows that parents mentioned when asked about science-related media, two parents could not think of any science-related apps or television shows that their child may have been exposed to informally. When asked for examples of science media, Parent 3 said, "I really can't think of anything. I think that's a niche that could be [filled]... unless we're just completely unaware." Whereas with math, each parent was able to give at least one example of either a television show or app that they believed incorporated math learning.

Although some parents seemed to struggle to identify science in television shows and apps, a subset of parents, who also identified science-related television shows and apps, described finding science media by searching for videos on YouTube or Facebook. Parents turned toward online video sources to display natural phenomena that they would be unable to replicate in their own homes (for safety or feasibility reasons) or to find inspiration for experiments they could conduct with their children. Parent 6 reported using YouTube to show her child experiments that are too dangerous for her

to do herself, "She has seen some stuff on YouTube before, like different people doing experiments like bigger rockets." Some parents described turning to YouTube to show their children videos of the natural world. For example, parents discussed showing their children videos of weather and natural phenomena.

Parent 1: "They will watch some of like the Earth shows or whatever. [...] Or they'll ask like... for some reason they're really into volcanos lately so they'll want to watch videos and ask how a volcano works." Researcher: "And where are you finding those videos?"

Parent 1: "On YouTube. Or just sort of Googling these videos, or a tornado, or sort of different weather phenomenon that they want to see what it looks like."

In addition to helping parents answer questions about the natural world, parents also utilized YouTube to quickly find videos to answer their child's science questions. Parent 12 recounted:

"One day... I was telling [my child] if you pour salt on a [clam], if it's alive, it might come out and we couldn't get it to work, so I went on YouTube and we found the clam and she just ...wants to watch it all the time... But yeah, so basically if there's something I'm trying to explain or she has a question, that's what we use."

Most parents in the sample described using internet videos to support their child's science inquiry and to encourage science curiosity and exploration. Only two parents (2 and 11) mentioned using YouTube as a math resource to find videos with math songs. In contrast to parents stating that they found math more easily than science in other forms of media, like television shows or apps, it seems that parents believe that internet videos supported more informal science learning than math learning.

4.3 Concerns about Online Video

Despite parents utilizing YouTube to answer their child's questions or spark science-related interest, some parents mentioned being particularly concerned about the videos their children may encounter when surfing YouTube, either through the videos that automatically play after watching an initial video, or the related videos that are recommended and shown adjacent to the first video. Parent 6 said:

"Now that she knows how to use the computer a little bit more, you put on like a music video of Trolls or whatever and then you come back five minutes later and she's like, 'Oh, I found something else!' and she's clicking on stuff. I can't let her go down that rabbit hole. [...] With YouTube, anyone can put anything on there and it's not always what the title says it's going to be. People are weird and try to sneak stuff in."

Parent 3 shared similar concerns about her child stumbling upon inappropriate content:

"There's crazy stuff out there and so little regulation. We've put parental settings but you still find like 'Batman surprise eggs' turns into inappropriately dressed people doing stuff with the Batman theme. I think YouTube is a big concern and there are many days where I'm just, 'oh my gosh we should just delete the ability for them to even get on the Internet.'"

Parents generally expressed concern about finding media that is appropriate for their child's age, educational level, or technical ability, and parents reported that they cannot always trust the labels that media designers apply to their content.

5 Discussion and Implications

The interviews from this study provide important insights into how parents identify and incorporate science and math media in their child's informal learning environment and areas where parents are missing support. We found that parents described media as being a supplemental tool for their children, using it mostly for reinforcing already learned concepts. Additionally, our findings uncover that parents have difficulty identifying some preschool science media in comparison to math, but do use online video to support science learning. This suggests that many parents are not using science television and apps as a means to reinforce science learning for their children in the same way they are able to do so for math learning. We believe this could be attributed either to children consuming less science media in comparison to other subject areas or because parents are less likely to recognize the science media their children are consuming. These findings complement other studies which found that parents believe their children learn less science than math or literacy skills from the educational media that they consume [14] and that parents have difficulty recognizing science in their everyday lives [26].

The interview results offer implications for how media designers and those within the IDC community can help parents utilize media for their children's early learning. Created content can provide prompts for parents to build upon learning opportunities present within content or help parents and children recognize math and science in their everyday lives from highlighted depictions. Content creators have an opportunity to design media that not only supports children's science and math learning but also educates parents about how they can interact with their child to promote science and math learning. Because parents reported experiencing difficulty recognizing science, media producers and content aggregators can design new experiences and augment existing content to clearly highlight when science concepts are present in media content and suggest ways that parents can interact with their child during media use or extend learning of the science concept to off-screen activities. Further work can evaluate how to embed these features into content and how parents and children respond to these types of features. Other efforts in the community have also focused on helping young users recognize the science that is already

occurring in their daily lives [1, 32], highlighting that this assistance with science recognition is a needed support across child ages. While the previously mentioned science-based technology efforts [1, 32] occur in natural settings, such as a child's classroom or neighborhood, many usability sessions often take place in laboratory settings. The work in this paper complements ongoing work in the IDC community to capture insight pertaining to the "at home" experiences of the children for which many of the digital and technological innovations within this community are designed [22].

Our results also illuminate that media is helping parents engage their children in science learning in ways not typically captured in traditional media diaries or media use studies. For example, we were surprised to learn how many parents turn to online video to quickly answer their children's science-related questions. Previous work from the IDC community found that YouTube was the most used media when children aged 5 to 8 years old were using a smartphone [10]. Online videos appear to be a great avenue for featuring quality science media because of their frequency of use by children, but families' use of them may be limited as parents are wary about the other inappropriate videos their children may find during use, a fear that recent research has been found to be widespread [21]. While this fear is very present, young children are still engaging with YouTube often [10], highlighting a platform that the IDC community should prioritize when conceiving of and disseminating future content.

Future research should expand the current constraints of capturing media use in order to properly gather data on how families might be engaging with educational media in novel ways, such as by watching online videos. Additionally, while this study focused on the informal learning environments of very early learners, other research has explored the tension that exists for parents of school-age children who desire to link informal learning at home directly to formal learning environments, such as the classroom through school-parent technologies [31]. Future research could explore if our implication that content creators should orient parents toward what constitutes math and science in their daily lives is also relevant for parents of older children.

5.1 Limitations and Future Directions

We conducted this study to provide initial, descriptive information about the context around parents' use of media to support science and math learning with young children. Our findings were shaped by the views of our study participants and we provide plausible interpretations from them [30]. However, there are some limitations of our study, including those that are associated with our chosen methodology and our small sample. Selection bias likely influences our findings as our recruitment call identified that science and math media and informal activities would be the focus of the interviews. Since grounded theory requires constant comparison and deeply engaging with the data, it is possible that different researchers working with a different sample would have

different findings than we explore here. We also relied on parent perceptions and report of their children's science and math media use instead of directly observing parents and their children in their own environments. Additionally, while our sample consisted of mothers of different racial and ethnic identities and income levels, we did not observe differences between what was said by our parents along these variations. We suspect a study utilizing a larger sample could find differences between groups that varied by these demographic factors as other large studies have found racial and economic variation related to media use [12, 13, 23, 25] and access [11, 12] by children and their parents. The findings from our small sample are not widely generalizable given the method of data collection, but these rigorous, in-depth findings address a gap in the literature by illuminating how parents in our study actually situated science and math media within their child's informal learning activities and parents' desires for support.

While these limitations should be considered, many elements were incorporated into this study design and analysis so that our study was not weakened by these limitations. We conducted pilot interviews to ensure that our semi-structured interview guide would elicit deep, rich data. Each transcript was reviewed by at least two researchers to confirm the data quality. We carefully documented our data collection, coding, and analysis processes. These elements display some of the ways we ensured that our data collection and analysis were of high quality and that our described findings were grounded in what was shared by our study participants.

We recommend that future studies extend our rich, qualitative findings by conducting observational or mixed methods research to provide a fuller understanding of the critical role media plays in children's lives. Nevertheless, our results contribute to the understanding of how families use media for informal science and math learning, and can help fellow researchers and media designers build upon how parents are already using science and math media with their preschool-aged children.

6 Conclusion

Our findings demonstrate that parents perceive media as an important tool in reinforcing science and math concepts for their preschool-aged children's learning. However, our findings also demonstrate that there are crucial differences between how parents identify and use math media compared to science media, with math being reinforced mainly via television shows and apps and science being explored through online videos. The goal of this research is not only to add to the literature on how parents are supporting early STEM engagement with media, but also to catalyze future design research that considers the nuanced way that parents use media as a tool for STEM education. In general, we hope this research can familiarize content designers with how parents interpret the media landscape, inform practitioners of how to meet parents where they are at, and help parents utilize educational media with their children.

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SELECTION AND PARTICIPATION OF CHILDREN

No children participated in this work.

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