Digital Media, Early Learning, and the Impact of Mediation on Child Learning Outcomes

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Abstract: Digital games and media resources are often designed to teach particular skills or concepts, and mediation can have an impact in supporting those intended learning outcomes. We refer to mediation to describe the role that an adult plays in supporting, guiding, and demonstrating game play as well as curation, or the sequencing or grouping of game play activities in targeted ways. We examine and describe ways in which educators, parents and families can mediate children's game-play and media use that can support positive learning outcomes in formal and informal learning environments. We also discuss how the curation of digital media experiences for children that are engaging and that integrate elements of a particular skill area can promote learning. To inform this discussion, we draw from multiple studies examining preschool-age children's use of digital media and the impacts on learning.

Introduction

The role of digital play and digital games in young children's learning lives has been both championed and challenged as the future of learning. Within this context, developers, designers, educators and researchers are just beginning to attend to the integral role that adults can play in mediating children's experience with digital media, as the questions shift from whether digital media can impact learning to the conditions under which it is possible to do so. What kinds of mediation are needed and in what environments? Findings from recent research suggest that adult mediation—such as selecting, curating, sequencing, supporting, guiding and demonstrating use--can play an important role in extending, enriching, and improving children's learning outcomes (Moorthy et al., 2013; Media and Learning Group at SRI Education, 2010; Stevens & Penuel, 2010; Takeuchi & Stevens, 2011). The studies described in this paper advance this line of research by identifying the extent to which educators and families adopt and utilize mediation strategies and promote interactions that increase the opportunity to learn in the moment.

This research is part of a summative evaluation of Ready to Learn, a children's public media initiative supported through the US Department of Education and conducted by EDC and SRI, that seeks to develop engaging, high-quality educational programming and supports for two- to eight-year-old children from low-income households. A core aim of the initiative is delivering early mathematics resources for new and emerging digital platforms such as tablet computers, interactive whiteboards, and smartphones, as well as better-established technologies such as computers, video displays, and gaming consoles, and to create learning experiences that leverage the unique capabilities of these various technology platforms for young children's learning.

This paper examines the role and impact of mediation in the context of early learning and digital media, including digital games, apps and video. We consider two kinds of mediation: content curation, which includes the sequencing or grouping of videos and game play activities in deliberate ways that are intended to target specific learning objectives, and joint engagement with media (JEM), which includes selecting, supporting, guiding and demonstrating digital media use. We draw on findings from two studies examining how games and media can support very young learners to acquire mathematics skills across learning environments. These studies include a Classroom-based Study that examined digital media use in daycare and prekindergarten classrooms and a Lab Study that examined preschool-age children's learning and digital media use in informal or "lab" settings. Across both contexts mediation emerged as a central component that expanded the impact of digital content on children's learning of target skills and concepts. Specifically, our results indicate that young children can learn targeted skills when they are engaged with well-designed media that takes into consideration children's developmental and learning trajectories and is supported through mediation.

Theoretical Background

Preparing children for school and learning across content and readiness domains presents a continual challenge. Many children enter kindergarten lacking important skills that predict later success in school, particularly mathematics achievement, which is an even stronger predictor of children's later school achievement than even

early literacy (Claessens, Duncan, & Engel, 2009). Digital media learning experiences, including developmentally appropriate educational digital games and videos, may provide an important means to develop young children's early learning skills.

Media, in the form of videos and games, can offer dynamic, multi-sensory representations of concepts, places, or people that would not be practical (or possible) otherwise. For example, children can use digital media for virtual field trips to remote habitats, or use interactive virtual manipulatives that provide immediate feedback and prompts to support mathematics understanding. Children can be intrinsically interested in and motivated by media and technology experiences, and this increased motivation is associated with deeper engagement and processing (Renninger, 2000). Children's engagement with these kinds of digital resources is associated with gains in literacy, science, and math and skills related to school readiness, such as approaches-to-learning (ATL) and problem solving (Fisch, 2004, Penuel et al., 2012; Pasnik & Llorente, 2013). Although digital games and media clearly hold potential for influencing learning, there is less consensus in the literature about the characteristics and conditions required for effective use. We hypothesize that adult mediation of children's use of digital games and media provides a central support for children's learning and conceptual understanding.

In addition to representing and organizing ideas in a different medium, educational technology and media can also foster social interactions, increasing communication and collaboration between and among teachers and students that can lead to the co-construction of deeper or extended conceptual understanding (Hong & Trepanier-Street, 2004). Joint engagements with media (JEM) builds on research showing that co-viewing educational television programming with adults or older siblings enhances young children's learning (Reiser, Tessmer, & Phelps, 1984; St. Peters, Huston, & Wright, 1989). JEM includes experiences in which adults and children interact with one another while simultaneously attending to a media artifact, such as viewing a video, reading a digital book, or playing a game on a mobile device. The collaborative conversations that occur in the context of a shared media experience may help children clarify concepts, internalize knowledge and develop deeper reasoning skills, and provide an opportunity for adults to assess and scaffold student thinking by asking questions or requesting elaboration and providing feedback; and model various strategies, such as thinking out loud and modeling discourse strategies. Adults can also provide basic support by guiding the use of technology and prompting interaction (McManis and Gunnewig, 2012). Reflective of the extensive research on the positive impacts of student-centered classroom discourse (e.g. Chin, 2007; Hiebert & Wearne, 1993), research on joint engagements with media suggests that this type of collaborative use can provide powerful affordances for learning beyond what the media resources may support through solo engagement (Moorthy et al., 2013; Media and Learning Group at SRI Education, 2010; Stevens & Penuel, 2010; Takeuchi & Stevens, 2011).

This paper also examines a second type of mediation related to the curation of content. We hypothesize that creating digital media experiences for children that are engaging and that focus on a particular target skill and are organized in a set learning sequence can provide distinct learning opportunities. Although there is limited research on use of content curation and digital media, literature related to instructional design and curriculum sequences suggests that the organization of learning experiences into a cohesive sequence is consequential for children's learning. Specifically, students who experience mathematics curricular interventions that are focused on a particular concept and that include a set of learning experiences and instructional tasks that are closely aligned to evidence about students' conceptual development learn more than students who experience more typical curricular approaches (Clements et al, 2011; Presser et al., 2010; Sztajn et al., 2012).

Research Questions

These studies address a core set of questions about the role of digital media (games, apps, video), mediation of that digital media experience, and how it can affect early learning among preschool age children. These questions include:

1. What are the ways in which educators, parents and families mediate children's game playing and technology use in formal and informal settings?

2. To what extent does attending to mediation throughout children's game-play and media use experiences impact learning outcomes?

3. To what extent does sequencing or grouping digital media (games, apps, and video) in targeted ways impact learning outcomes?

Data and Methods

Two recent studies demonstrate the role that mediation can play to support mathematics learning for four-year-old children. These studies took place in two distinctly different contexts and environments. The first, a Classroom-based Study, took place in typical early-learning classrooms where educators were asked to implement a series of digital media activities, designed as a curriculum supplement over several weeks. The second, a Lab Study, took place in an informal, controlled environment or what we describe as a "lab" setting, where children were exposed to a sequenced set of digital activities targeting specific math skills with minimal intervention from adults in the room.

Study 1: Classroom-Based Study

The classroom-based study was designed to investigate whether the experience of implementing a 10-week curriculum supplement that curated media-rich as well as non-media activities in a set learning sequence would support children's growth in target mathematics skills including counting; subitizing; recognizing numerals; recognizing, composing, and representing shapes; and patterns. Teachers and children in New York City and the San Francisco Bay Area from 86 preschool classrooms serving diverse, urban, and predominantly low-income populations were randomly assigned to one of three conditions: a Media-Rich Math Supplement condition, a Technology & Media condition, and a Business as Usual control condition. The Media-Rich Math Supplement condition provided classrooms with digital tools (i.e., interactive whiteboards and tablet computers), instructional support (i.e., coaches), and a structured curriculum supplement that supported teachers in integrating digital media into regular classroom instruction and routines. The Technology & Media condition provided the same digital tools and instructional support as the Media-Rich Math Supplement condition, but did not provide a curriculum supplement for guiding the selection and use of the digital resources. Teachers in the Business-As-Usual condition continued to engage in their typical mathematics activities without the addition of any digital tools, instructional support, or curriculum supplement.

Teachers in the Media-Rich Math Supplement condition enacted a 10-week curriculum supplement, which included media-rich activities, centered on videos and games available via public media broadcasting and online services, and non-digital, hands-on activities. A Teachers' Guide provided sequenced activities across the 10 weeks focused on targeted math skills, as well as scaffolds for instructional mediation, including; suggestions for when teachers should pause videos and game play to initiate discussion, prompts for facilitating discussions with children, and facilitation notes for warm-up and wrap-up discussions to extend and enrich learning. These scaffolds were designed to support classroom discourse and a shared media experience.

Child outcomes were measured through two early mathematics assessments: a short version of the Research Based Early Mathematics Assessment (REMA short form) (Weiland et al., 2012), which served as a standardized assessment of children's mathematics skills, and a supplement-based assessment (SBA) developed by the research team to be closely aligned to the mathematics concepts targeted in the Media-Rich Math Supplement and the Technology & Media conditions. Teacher outcomes were measured through administration of a pre and post teacher survey.

Study 2: Lab Study

The Lab Study was designed to explore, in a controlled environment, the extent to which children can learn mathematics from PEG+CAT resources outside of instructional environments and relationships; how parents perceived the resources; and how well children engage with these resources independently. The study used a pre/post design with no comparison or control group and included 59 child participants and their families from the New York metropolitan and San Francisco Bay areas. The treatment included five weekly sessions, each lasting approximately one hour. These sessions occurred in a laboratory setting and each week children and their parents met with a researcher who administered pre- and post assessments and guided viewing and gameplay of the PEG+CAT resources.

Prior to the beginning of the study, researchers conducted a detailed review of all learning materials developed by *PEG+CAT* producers, closely attending to focal mathematics skills and the strategies designers used to support learning. Following review, researchers selected specific *PEG+CAT* content that targeted two mathematics skills—patterns and shapes (3D/2D)—and the videos and games children engaged with during the study were selected and sequenced in a carefully curated experience to address these skills. Researchers selected and sequenced the videos and games such that children would have more than one opportunity to engage with a particular mathematics skill.

To examine children's mathematics knowledge, the research team relied on two tools. One was the REMA, (Weiland et al., 2012), and the other a researcher-developed assessment. Researchers needed an additional measure because the *PEG+CAT* resources addressed mathematical skills that are not necessarily the focus of the REMA (e.g., auditory patterns and 3-D shapes). Researchers were also interested in assessing children's understanding of focal mathematical skills immediately following the opportunity to learn them through exposure to the PEG+CAT resources. Therefore, researchers developed the PEG+CAT Item Sets (PCIS), which were closely aligned to PEG+CAT experience and administered before and after the sessions during which children engaged with media that targeted specific skills.

Findings

Findings across the two studies indicate that digital media interventions that: (a) are designed to present activities in a particular sequence and target specific skills or concepts, and (b) include scaffolding for engagement in rich discussion and interaction with adults regarding the digital media (JEM), hold significant potential for increasing preschool-age children's learning.

Children who engaged with the media-rich classroom curriculum incorporating a curated set of digital media experiences improved significantly in their understanding of key early mathematics skills essential for early school success. While teachers whose classrooms received an infusion of digital resources (Technology & Media condition) integrated new technology tools and media resources into the mathematics lessons at quite high rates, and teachers whose classrooms were unaltered by the study (Business as Usual condition) spent considerable time and effort supporting children in learning basic math skills, it was only the children in the Media-Rich Math Supplement group who improved significantly in their mathematics skills (see Table 1).

Observation data from the classroom-based study indicate that teachers from the Media-rich math supplement typically implemented the distinctive features of the curriculum: the warm-up and wrap-up, pause points where teachers engaged children in discussion about content, and the JEM instructional strategies emphasized in the curriculum supplement. Teachers used pause points as specified in the Teacher's Guide 95% of the time during video viewing, often adding additional pause points of their own to reiterate ideas, check children's comprehension, and ask questions to spark discussion, which centered on the mathematics knowledge and skills that were highlighted in the Teacher's Guide. Moreover, teachers typically incorporated the recommended JEM instructional strategies into their enactment of activities: teachers modeled activities for children in 89% of observed activities, thought out loud in 85% of observed activities, encouraged children to think out loud in 73% of activities, re-voiced children's ideas in 80% of activities, and encouraged children to provide feedback to their peers in 58% of activities. This focus on attending to mediation, in the form of JEM strategies, supported children's improved understanding of early mathematics skills.

Impact Contrast	Coefficient	Std. Error	Hedges' g (Effect size)	p	Multiple Comparison Test*
SBA					
(1)PBS KIDS Transmedia Math Supplement vs Business as Usual	1.51	0.302	0.24	<0.001	significant
(2) Technology & Media vs Business as Usual	0.08	0.309	0.01	0.789	---
(3) PBS KIDS Transmedia Math Supplement vs. Technology & Media	1.43	0.288	0.22	<0.001	significant
REMA					
(1)PBS KIDS Transmedia Math Supplement vs Business as Usual	1.09	0.589	0.15	0.064	---
(2) Technology & Media vs Business as Usual	0.00	0.587	0.00	0.996	---
(3) PBS KIDS Transmedia Math Supplement vs. Technology & Media	1.09	0.571	0.15	0.056	---
HTKS					
(1)PBS KIDS Transmedia Math Supplement vs Business as Usual	-0.02	1.432	0.00	0.991	---
(2) Technology & Media vs Business as Usual	-0.89	1.460	-0.05	0.542	---
3) PBS KIDS Transmedia Math Supplement vs. Technology & Media	0.87	1.370	0.05	0.524	---

*Note: thresholds for statistical significance adjusted for nine pair-wise comparisons using the Benjamini-Hochberg False Discover Rate procedure.

Table 1: Summary of PBS KIDS Transmedia Math Supplement Impact Estimates

Results from the Lab Study indicate that children who participated in the curated media experiences delineated in the study design, showed positive shifts in identifying some geometric shapes on a researcher-developed measure aligned to the media-based intervention and in overall math skills on the REMA short form. Children's per-

formance improved significantly from pretest to posttest on a shape identification task on a researcher-developed measure aligned with the resource study experience. On additional shape identification and pattern tasks children showed positive but non-significant gains on the same measure (see Table 2).

PEG+CAT Episode/Game	Target Skill	Description of item	Pretest		Posttest		Change Pre to Post	
			% Correct	n	% Correct	n	% Correct	n
Big Gig Patterns	Pattern Completion	Using a screenshot from the *PEG+CAT* Game App, The *Big Gig*, the assessor slides their fingers across a 1, 3, 1, 3 pattern, then asks the child to tell them what number comes next.	35.59%	21	54.24%	32	18.64%	11
The Golden Pyramid Problem	3D Shape recognition	The assessor places the following 3D shapes in a basket: sphere, cube, cylinder, and pyramid, then asks the child to point to or pick up the cube.	38.98%	23	55.93%	33	16.95%	10
The Golden Pyramid Problem	3D Shape recognition	The assessor shows the child images of various 2D and 3D images from the *PEG+CAT* video, *The Golden Pyramid Problem*, and asks the child to point to the cylinder.	38.98%	23	54.24%	32	15.25%	9
The Golden Pyramid Problem	3D Shape recognition	The assessor places the following 3D shapes in a basket: sphere, cube, cylinder, and pyramid, then asks the child to point to or pick up the cylinder.	54.24%	32	67.80%	40	13.56%	8
The Golden Pyramid Problem	3D Shape recognition	The assessor shows the child an image of Mermaid holding pyramids from the *PEG+CAT* video, *The Golden Pyramid Problem*, then asks the child what shape Mermaid is holding.	3.39%	2	15.25%	9	11.86%	7

Table 2: PEG+CAT Item Sets items for which noteworthy pre-post gains were observed.

Mediation: Adult Intervention, Support, Guidance and Demonstration

Two specific themes emerged from these studies: (a) the role of mediation in the context of children's experience with digital media; and (b) the substantial role of content and sequence in a child's experience of the media and, by extension, exposure to and understanding of identified target skills.

Findings from our classroom-based study point in particular to content curation as an important mediator. Children who were part of the Media-Rich Math Supplement group significantly improved in their mathematics skills as a result of their participation, in contrast to children in a condition where similar technology devices and content were available, but not mediated through any curation of content. This suggests that organizing content into a cohesive learning sequence and providing support for teachers to enact joint engagement with media strategies (pausing to ask questions, making connections) can lead to positive child learning outcomes.

The differences in learning outcomes across the two groups suggest that for digital games and media to impact learning, the design must attend to both the content focus and the sequence in which it is experienced. Without the benefit of a set of sequenced activities, teachers in the comparison Technology and Media group were required to first locate and then match resources to classroom mathematics activities and then had to continue this process over 10 weeks in order to create larger arcs of lessons to ensure children had the repeated, linked opportunities to learn a set of target math skills. Few early childhood educators have the level of intimate knowledge about a set of digital resources that would allow them to construct such a multi-week experience for their students without the benefit of substantial planning time and guidance from content area experts.

Our Lab study of the *PEG+CAT* resources provided the opportunity to further explore the role of mediation. While the initial structure of this study sought to eliminate all mediation from children's experiences during the study, researchers acknowledged the hidden mediation built into the experience for all participants. For example, children engaging in a completely "natural" media experience can leave or click away from a particular resource at any time—however the design of the study website made this very difficult. Children engaging with content are constrained by the content's public release, however in our study we had access to all content and could make viewing selections based on knowing the full range of available options. Each of these instances requires input from adults that mediates children's experience. Given this fact we designed the lab study to emphasize the curation of content (which did not require direct contact with an audience) and de-emphasize the role that could be played by JEM (which requires direct contact). The resulting study and findings suggest that children can gain new skill and content knowledge through exposure to a well curated and sequenced set of interrelated activities, even when JEM opportunities are not available.

Conclusion

Results from our studies suggest mediation is a crucial component to any digital experience that targets young children and has as its goal a specific learning outcome. Key mediators include: adult intervention or support and curated content that is developmentally appropriate for the target audience and structured in a systematic way that introduces concepts and skills sequentially—for example introducing new concepts or skills during the first experience, and offering practice opportunities during later experiences. Much effort has been expended on the development of well crafted and engaging digital media that attempts to blend learning with gaming or play activities, yet few studies have been able to document strong positive learning outcomes from these experiences, particularly for young children. We suggest mediation can play a substantial role in supporting children's learning in digital environments, and that attending to the role of mediation in its various forms can benefit children and the adults working with them. If digital tools are to play a role in supporting learning for all students, then careful consideration must be given to the circumstances that make these tools usable by all students. Providing children and their care-providers with access to content that is both well made and thoughtfully organized based on understandings of developmental and learning trajectories, can give children a chance to grow skills, and move forward the role of digital media in children's learning.

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