Chapter 10. Designing joint engagements with media to support young children's science learning

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Young children are positively disposed to and a capable of developing sophisticated science, technology, engineering and mathematics (STEM) skills and knowledge. This chapter reviews the literature related to children's development of early science literacy and how designed joint engagements with media (DJEM) can, by providing rich opportunities for joint attention and academically productive talk, play a powerful role in helping children build strong early science skills and content knowledge. The chapter proposes a theory of designed joint engagement with media based on a classroom enactment of the DJEM approach and unpacks the implications of DJEM on technology development and future research.

Context

One of the world's most pressing challenges is how to provide all children, regardless of birth, with formal and informal science learning experience necessary for them to develop the scientific literacies required to participate fully in public life and have the option of pursuing careers in science, technology, engineering or mathematics (STEM) fields. This chapter explores how theories of joint attention and academically productive talk, two cornerstones in learning sciences theory and research, with empirical research on the motivational and attentional affordances of increasingly ubiquitous technology and media resources, can be leveraged to support early science learning and teaching. Readers interested in further reading on media and learning and/or early science are especially encouraged to consider chapters by Barron and Levinson and by Toub, Verdine, Hirsh-Pasek and Golinkoff in the current volume (Chapters 9 and 16).

Early science and educational media

There is a growing awareness that science learning needs to begin early in childhood. Research suggests young children are not only capable of, but also benefit greatly from, making sense of the world around them by using foundational science practices to develop deep understandings of life, earth and physical science content (National Research Council, 2012[1]). Focusing on early science can benefit all children, but can be especially powerful for young children from disadvantaged groups who are historically underrepresented in science careers (Landivar, 2013[2]). This chapter describes an approach around the use of technology and media to address this need and bridge this gap: Designed Joint Engagements with Media (DJEM).

While the use of technology and media early in childhood has been historically controversial largely due to concerns about the effects of screen time on young children's health and well-being, researchers and practitioners now agree that technology and media that is designed and used in developmentally appropriate ways can be a powerful resource and catalyst for learning (NAEYC and Fred Rogers Center, 2012[3]). This is especially true for science, where technology and media can allow access to varied content (and content that may often be hard to access) and provide powerful representations and models (Kallery, 2011[4]). Appropriate design and use of technology and media early in childhood hinges on ensuring it promotes social and collaborative learning processes, rather than isolated learning as many fear. The DJEM approach described in this chapter builds on developmental and learning sciences theories and empirical research to delineate processes that can ensure technology and media support learning in socially rich ways.

The chapter describes research effort aimed at testing the DJEM approach on the ground, including the development and field-testing of a curricular supplement that uses a curated set of engaging and developmentally appropriate video clips from Sid the Science Kid to organise and support educationally productive talk to promote engagement in science practices and understanding of science content.

Possibilities and challenges of supporting early science learning

Young children have an abiding curiosity about the natural world, are ready to engage in science practices, and can think deeply and, to a degree, abstractly about scientific concepts (Gelman and Brenneman, 2004[5]). For example, pre-schoolers at home and at school are often interested in observing and documenting their own growth or the growth of plants

and are eager to explore structures and investigate how things move through building (and knocking down) blocks.

Early science learning has been associated with long-term positive outcomes, in particular, how knowledge of the social and physical world strongly predicts later academic achievement in reading and science (Grissmer et al., 2010[6]). Research has documented that high quality early science instruction is significantly associated with improved vocabulary and grammatical complexity (French, 2004[7]; Peterson and French, 2008[8]), mathematics learning (Epstein, 2007[9]), executive function (Nayfeld, Fuccillo and Greenfield, 2013[10]), school readiness (Greenfield et al., 2009[11]) and later academic achievement. Of course, children need support and scaffolding from adults to make these possibilities a reality.

Unfortunately, preschool science learning opportunities are few and far between, and preschool teachers are not often prepared to lead when it comes to science teaching. Currently preschool programmes, especially those serving children from low-income communities, offer children few planned (Nayfeld, Fuccillo and Greenfield, 2013[10]) or free-choice (Nayfeld, Brenneman and Gelman, 2011[12]) opportunities to engage in science learning. And while teachers play a critical role in scaffolding children's science learning, many early childhood educators lack the preparation and confidence needed to promote science in their classrooms, and the necessary instructional resources to integrate science into their curricula (Dominguez et al., 2015[13]). Given these circumstances, new resources and innovative methods are needed.

Leveraging educational media and technology for early learning

Decades of research on young children's learning with educational technology and media highlight their potential to support academic learning (Fisch and Truglio, 2000[14]). Educational technology and media can be valuable learning tools in preschool classrooms by promoting (National Research Council, 2012[1]) representation and organisation of ideas in a different medium, (Landivar, 2013[2]) communication of ideas and collaboration among members of a learning community (NAEYC and Fred Rogers Center, 2012[3]), visualisation and reflection on thinking of children and teachers (Kallery, 2011[4]) and extension and communication of consolidated learning (Hong and Trepanier-Street, 2004[15]). Developmentally appropriate integration of digital resources using resources that foster engaging interactions with content, peers and teachers can facilitate literacy and STEM learning in preschool settings and beyond, particularly for children from socially and economically disadvantaged populations.

Short videos, for example, can provide young children with the opportunity to observe and discuss phenomena and concepts that would not normally be accessible in classrooms given time and resource constraints (Kallery, 2011[4]). Videos can also feature characters that model engagement in science practices, which can prove beneficial for both children and adults scaffolding their learning (Dominguez, Sharifinia and Danae, 2015[16]). Mobile devices, such as tablets with touch screen technology, can also provide unique opportunities to promote science learning by allowing children to document their investigations and collect data they can revisit to reflect on their findings and by providing access to apps with unique opportunities to practice what is learned in the real world. Based on these findings, our theory of designed joint engagements with media proceeds from the insight that when technology and media use was associated with outcomes in empirical studies, it was often designed with certain features (like discussion prompts) and used in specific contexts (that

supported or enabled co-engagement) that maximised the social dimensions of learning. The following section defines and unpacks the theory in detail.

A theory of Designed Joint Engagements with Media (DJEM)

We define DJEM as purposefully created, shared experiences where individuals interact with one another while simultaneously attending to a media artefact. DJEM can take many forms, including viewing a video, playing a game on a mobile device or reading a digital book together. DJEM grows out of the idea that joint attention or the co-ordinated focus of all interacting individuals on the same phenomena, is a necessary condition for joint engagement and is fundamental to human learning from an early age (Meltzoff et al., 2009[17]). Because the management of attention is fundamental to interactions (Barron, 2003[18]), DJEM also depends on theories of collaboration that highlight how attention is recruited, sustained and leveraged during interactions. Both the speaker and the listener play an important role in establishing, monitoring and sustaining joint attention during interactions, drawing both on non-verbal communication (e.g. pointing, moving to share visual perspective, etc.) and on meta-communicative verbal comments. The use of such strategies helps create a 'between-person state of engagement' that draws on both the cognitive and the social dimensions of communication (Barron, 2003[18]), and helps partners develop a shared conceptual structure in which they collaborate and learn as they engage with media together.

DJEM is informed by research on other forms of joint engagement, including studies that illustrate how collaborative parent-child conversations support young children in their zone of proximal development to reason and solve problems with increasing sophistication. These shared conversations – joint social engagements – serve as sites for knowledge construction and meaning making. A considerable body of research suggests that everyday adult-child conversations helps children learn about the physical, natural and psychological world (Jipson and Gelman, 2007[19]). Founded on shared experiences, knowledge and interests, conversations between children and adults help make children's implicit knowledge explicit (Taumoepeau and Ruffman, 2006[20]) and support children's ongoing construction and understanding of concepts, taxonomies and complex arguments. The collaborative nature of conversations with adults helps make children's knowledge explicit (Taumoepeau and Ruffman, 2006[20]); supports their engagement at a higher level of reasoning and problem solving; provides an opportunity for adults to model various strategies, such as thinking out loud, asking questions, requesting elaboration; and offers children a rich source of information regarding the norms and practices (Callanan, 2006[21]) for participating in a discourse community (Callanan, 2006[21]).

Inspired by Barron (Barron, 2003[18]), we conceptualise media experiences as a particular kind of shared space where children and their social partners can jointly address learning issues. DJEM also builds on research on co-viewing and joint media engagement (Fisch et al., 2008[22]; Takeuchi et al., 2011[23]), that shows that co-engagement with educational television programming with adults or older siblings can be favourable for young children's learning (St. Peters, Huston and Wright, 1989[24]). Previous television research suggests that caregivers who watch together with children could initiate conversations about programming that fostered learning, such as naming and identifying objects, repeating new words, asking questions, relating content to the children's own experiences, and inviting and scaffolding the children to make connections between the programme and their everyday life (Bronfenbrenner and Morris, 1998[25]; Mihalca and Miclea, 2007[26]). In the changing landscape of media use with young children, there is a growing awareness that

media can support learning by promoting – rather than inhibiting – social interactions among children and between adults and children. Shared media experiences have the potential to act as a tool for scaffolding children's learning (Bronfenbrenner and Morris, 1998[25]; Mihalca and Miclea, 2007[26]; Vygotskiĭ and Cole, 1978[27]) through interactions, active mediation strategies, which encompass critical conversations between adults and children that refer directly to the media experience (Nathanson, 2001[28]) and experiential mediation, which involves the use of media as a platform for making sense of other experiences and interactions (Jennings and Walker, 2009[29]).

In DJEM, media acts as a powerful referential resource that provides a space for the highly co-ordinated, consequential social interactions that lead to learning. In various formats, media can support learning by providing a means of exposure to new ideas that can be explored more deeply in conversations. For example, a video's use of a rotting pumpkin to signify decay becomes a point of reference for facilitating discussion about how fruits and vegetables change over time and children's own experiences of decay. Developmentally appropriate media assets (e.g. educational television and videos, games, applications) can also catalyse social interactions (between adults and children and among children) that in turn activate important processes productive for learning. These include, but are not restricted to: participating in discussions; having opportunities to explain one's thinking about phenomena; listening to, eliciting and elaborating explanations; observing the modelling of language and meaning-making strategies; asking questions; evaluating and critiquing responses, and arguing to resolve differences. In this spirit, collaborative conversations that occur between adults and children in the context of a shared media experience help make children's knowledge explicit, support children's engagement at a higher level of reasoning and problem solving, and provide an opportunity for adults to model various strategies, such as thinking out loud, asking questions and requesting elaboration (Callanan, 2006[21]; Fisch et al., 2008[22]; Mihalca and Miclea, 2007[26]). Taken together, these lines of research form the foundation for the DJEM approach that explicitly integrates media experiences to support early science teaching and learning through social, media-rich, talk-centred experiences.

Classroom enactment of the DJEM approach

To test the feasibility and promise of the DJEM theory, we developed and refined a curriculum supplement, worked with a public preschool teacher partner to enact the supplement in her classroom, and conducted a preliminary exploratory study during the enactment. The teacher-partner's class of 20 children was ethnically, economically and linguistically diverse, and included many English learners. To increase the depth and quality of implementation, the teacher received coaching and on-site support from research team members before and during the implementation period.

The curriculum supplement comprised an eight-week experience on change and transformation, foundational concepts across science content areas. Modules were two weeks long and included two or three days of instruction each week that integrated video episodes, classroom discussions, teacher guided book readings and hands-on investigations. The curriculum supplement's four modules targeted type of change that children likely observed in their daily lives: decay, growth, reversible change and irreversible change. The videos that anchored each module were from Sid the Science Kid, an animated science programme for preschool children by the Jim Henson Company that explores everyday phenomena and provides models of science practices and science talk. Each Sid the Science Kid episode centres on a question that preschool-aged Sid, the

inquisitive main character, has about the world and why things work the way they do. Through the process of uncovering the answers to Sid's questions, the show exposes children to the big ideas of science, helping them deepen their understanding of everyday experiences by showing how science practices support the development of scientific understandings.

The video segments preceded and provided the anchor for teacher-led, hands-on activities, during which children explored phenomena first hand. An introductory whole class activity, structured around a video excerpt, introduced science topics and provided models for how children and teachers can engage in scientific practices to explore the topic in depth. This introduction was followed by four instructional days that offered a combination of whole class and small group activities that deepened and reinforced target concepts. Whole class activities included guided book reading, focused video viewing and reflective discussions. Small group activities, such as hands-on investigations (sorting/sequencing activities and data collection/recording tasks) were designed to allow children greater opportunities to engage in and discuss science. Each module concluded with a whole class discussion, facilitated by the teacher, during which children reflected on what they had learned about the science topic.

The curriculum modules were designed to provide children multiple points of entry and the opportunity to move back and forth between media-rich and hands-on activities, each time using previous experiences to create stronger and more nuanced understandings as they reengaged with concepts multiple times. For example, after watching the episode, "My Mushy Banana", students conducted observations of a banana, using their senses of sight, touch, smell and taste; they then recorded their observations in their science journals by drawing and labelling pictures (with the help of their teachers).

Technology and research implications

Anchored in foundational theories of learning and empirical research, DJEM has the potential to guide design and implementation of developmentally appropriate media and media-rich preschool interventions. For media makers, DJEM theory suggests they can and should create educational media resources that are, at a minimum, amenable to joint engagement – videos, games and apps that are aimed at kids working together with peers, teachers or family members. Moreover, there is an opportunity for the development of a new genre of apps designed specifically for parents that can support and foster rich conversations and social experiences shown to support learning. One example of this is the Daniel Tiger app developed by the Fred Rogers Company and their partners. Another is a new genre of app for parents called a Conversation Catalyst currently in development by media producers at The Jim Henson Company and Curious Media, in collaboration with authors from Digital Promise's Learning Sciences Research team. This design-based research effort will create new early science learning resources for parents focused on ocean science, and a series of empirical studies about their implementation and effectiveness.

DJEM theory provides a foundation for other empirical research. DJEM ideas have guided the recent design and development of technology and digital resources in the Next Generation Preschool Science (NGPS) project and interventions developed in CPB-PBS Ready To Learn research. Empirical research from these studies will, in time, provide additional evidence of the promise of enacting DJEM principles at scale.

Theoretically, DJEM extends the research on joint engagement and co-viewing by demonstrating how media can be a powerful resource for situated meaning making. by

generating a typology of interactions and real-world examples. This work adds to the growing body of research that illustrates how media can enhance the conditions for early learning by fostering productive interactions between adults and children. More practically, our findings offer strategies for using media to catalyse discourse and interactions, especially in domains like science that tend to be under-emphasised in early childhood education. Moreover, data support preliminary inferences about the types of interactions that might be especially challenging for teachers to orchestrate in the classroom, highlighting how curriculum materials and professional development may explicitly support teachers in scaffolding rich, productive interactions among children. Though this chapter focuses on early childhood science learning, the findings around joint engagement with media may be generalised to other learning contexts and content areas.

Policy implications

Innovative public policies are needed to make rich, shared media experiences as common at school and at home as shared storybook readings are today. As in the case of shared book reading, public policies are needed to encourage the creation of supports and resources that can transform the countless media experiences that children engage in (at school, at home, and in third places) into rich, social early-learning experiences. In addition to public policies that support and encourage development, policies and direct investments in research that supports the understanding and further development of models and genres of DJEM are urgently needed.

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