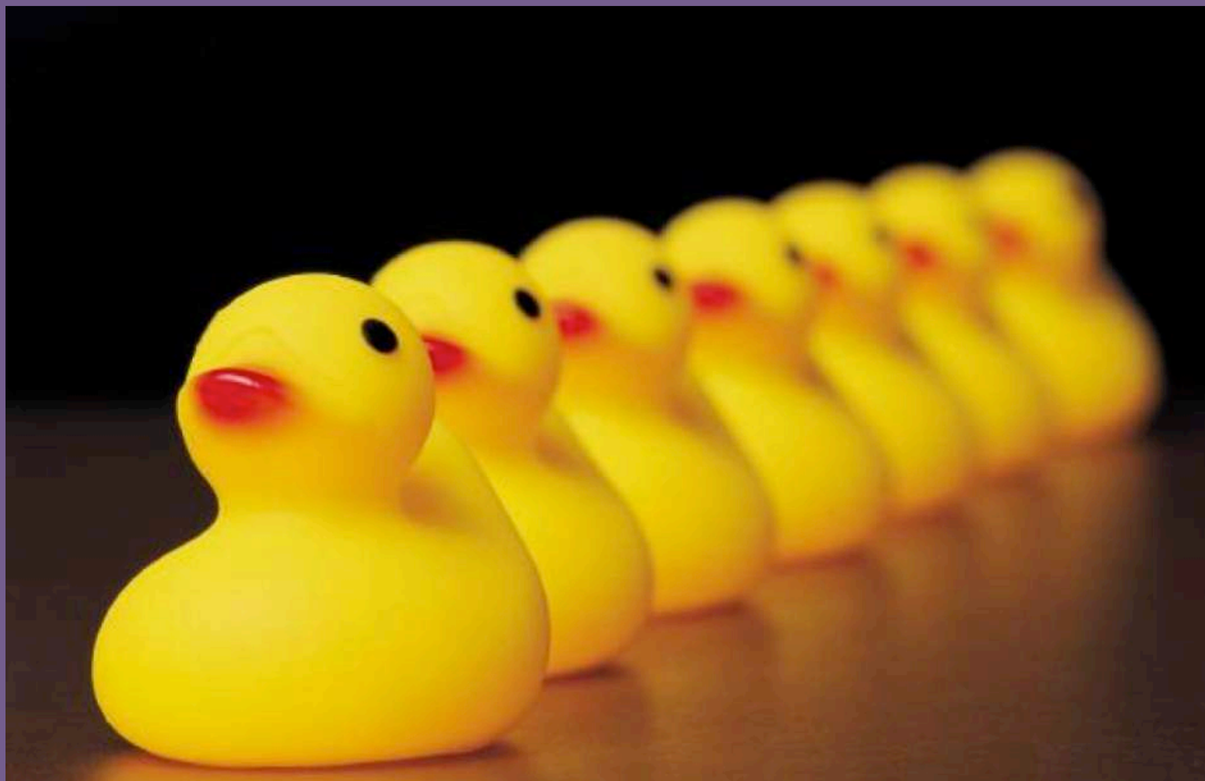

Using Educational DVDs to Enhance Preschoolers' STEM Education

A Collaborative Project Funded by the National Science Foundation
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Northwestern University
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Abstract

American students under-perform in the domains of mathematics and science, undermining the intellectual and economic potential of future generations. Researchers have proposed that meaningful exposure to science, technology, engineering, and mathematics (STEM) concepts through mass media and interactive technology platforms may augment learning in young children. Consequently, leading experts in the fields of communications and media studies, cognitive and developmental psychology, computer science, human development, and education gathered at Northwestern University in June 2014 to discuss findings across these fields that can contribute to the debates about children's STEM learning through interactive media and to formulate a series of research projects that might address these complex issues. This report highlights key points of discussion with the hope of catalyzing further discussion, inquiry, and research.

Introduction

Richert, Calvert, and Wartella received a 5-year NSF grant (#DRL-1252146) entitled *Using Educational DVDs To Enhance Preschoolers' STEM Education* to study how media characters can be used in STEM education. On June 2, 2014, the principal collaborators hosted a two-day workshop at the Center for Media and Human Development at Northwestern University entitled *Developing Intelligent Agents For Early STEM Learning*. The purpose of the workshop was to bring together leading experts in the fields of communications and media studies, cognitive and developmental psychology, computer science, human development, and education to engage in meaningful discussions pertaining to the impact of mass media exposure, as well as interactive technology, on children's early learning. Specifically, the principal collaborators were interested in eliciting conversation around two main themes: (1) determining the types of relationships that young children form with on-screen characters and (2) discovering how perceptions about these characters influence what children learn with regards to STEM content.

Interest in these particular themes stemmed from that fact that young children have experienced increased exposure - as well as access - to mass media and interactive technology (Common Sense Media, 2013). Previous research demonstrates that these platforms have the power to influence what children are able to learn vicariously from the world around them (Common Sense Media, 2013; National Association for the Education of Young Children and the Fred Rogers Center for Early Learning and Children's Media, 2012; Fisch & Truglio, 2001). Moreover, there is a growing awareness that socio-cultural factors, like ethnicity and socio-economic status, may be used as additional lenses through which to examine these issues.

Background

In recent years, children have experienced increased exposure to interactive technologies, such as televisions, computers, game boxes, tablets, and smartphones. Television remains the most prominent platform for young children, such that 90% of 3- to 5-year old children watch television on a daily basis (Gutnick, Robb, Takeuchi, & Kotler, 2010). This finding crosses both ethnic and socio-economic lines (Gutnick et al., 2010). Meanwhile, other technologies, especially those with an interactive component (e.g. video games, tablets & smartphones), are gaining traction with a vast increase in mobile digital devices such as smartphones and tablets in homes with young children in just the past two years (Common Sense Media, 2013).

Given the growing ubiquity of mass media and interactive technology in children's lives, it would be remiss not to consider the implications of these platforms on children's learning. Previous research has demonstrated that children learn vicariously from the world around them (e.g., Bandura 1977, 1986, & 1997). Thus, one could hypothesize that interactive technology, paired with the known benefits of high quality educational television programming (e.g. Fisch, Kirkorian, & Anderson, 2005; Fisch, 2004; Mares & Woodard, 2001; Bryant, Mullikin, Maxwell, Mundorf, Mundorf, Wilson, Smith, McCollum, & Owens, 1999; Hall, Esty, & Fisch, 1990; Hall, Fisch, Esty, Debold, Miller, & Bennett, 1990), could change the landscape of young children's learning, especially around STEM concepts. Presumably, these platforms would provide an informal cognitive bootstrap for learning, though this remains an empirical question (Brown, Kane, & Echols, 1986; Crisafi & Brown, 1986; Daehler & Chen, 1993; Goswami, 2001; Holyoak, Junn, &

Billman, 1984; Kim & Choi, 2003; Richert, Shawber, Hoffman, & Taylor, 2009; Singer-Freeman, 2005; Tunteler & Resing, 2002).

Screen characters are pervasive within mass media aimed at young children (Vandewater, Bickham, Lee, Cummings, Wartella, & Rideout, 2005; Calvert & Richards, 2014). These characters can hold such a prominent place in children's lives that they often become objects of affection in parasocial (i.e., one-way) relationships that proceed only from viewer to character (Giles, 2002). Yet, children may feel as if the relationship is being reciprocated, due to perceptions of social contingency. Given these strong bonds, one could anticipate the impact of these relationships on learning.

Only a few studies have examined the interaction between social cognition – in the form of parasocial relationships with media characters – and children's learning in general (Lauricella, Gola, & Calvert, 2011;; Richert, Robb, & Smith, 2011) and STEM learning more specifically (Calvert, Richards, & Kent, 2014;. Gola, Richards, Lauricella, & Calvert, 2013). Therefore, our understanding of this interaction would definitely benefit from lines of inquiry aimed not only at learning from parasocial relationships, but also learning as a function of digital platform. This is the focus of NSF Grant No. DRL-1252146.

Developing Intelligent Agents for Early STEM Learning

Overview

In an attempt to achieve the outcomes described above, the workshop was organized into two parts. First, the principal investigator for each site presented their lab's most recent findings around the topics outlined above. Second, these presentations were followed by panel discussions in which workshop participants considered questions meant to build upon these topics. A principal collaborator facilitated each discussion.

Presentations & Panel Discussions

Rebekah A. Richert, Ph.D.
Childhood Cognition Lab
University of California, Riverside

Perceptions of Characters May Influence Preschoolers' Learning. The Childhood Cognition Lab has taken a social cognitive approach to understanding influences on children's early learning. A main tenant of this approach is that learning occurs within a social context and should be viewed with that lens. Specifically, children are social beings who not only *act upon* the world around them, but are also *acted upon* (e.g. Bandura 1977, 1986, & 1997). As a result of these reciprocal influences, children learn by seeing, as well as by doing. This premise is often referred to as vicarious learning.

In building upon the idea that children learn by observing others, one could argue that exposure to characters, especially those who are socially meaningful, could potentially influence early learning. Preliminary evidence supports this notion (Lauricella, Gola, & Calvert, 2011). Richert and colleagues seek to extend these findings by determining the underlying mechanisms of vicarious learning. They propose two hypotheses: either (1) a child perceives his/herself as similar to the character in question or (2) a child perceives him/herself as *dissimilar*, such that the character in question is more effective in a particular domain than the child him/herself. Richert and colleagues tested these hypotheses by exposing young children to video clips of one of four socially meaningful characters; namely, Dora & Diego from *Dora the Explorer* and Gabriela & *Sid from Sid the Science Kid*. In each clip, the character presented a novel problem and its solution to the child viewer, who was then asked to solve the same problem. Preliminary findings suggest that about half of the participants are able to extract appropriate problem-solving strategies from the video clips to solve the analogous problem successfully. Yet, it is unclear as to why *some* rather than *all* children are able to achieve success. Therefore, future work will examine possible mechanisms including, but not limited to (1) identifying with particular characters or (2) regarding particular characters as efficacious within a particular environment.

Panel 1: STEM Skills & Literacy in Early Childhood

"Early math predicts later math and later reading, as well as early literacy."

~ Douglas Clements

In strengthening educational practices around STEM, a crucial first step is to determine the types of skills necessary for creating a strong foundation in these disciplines. Yet, this is often hampered by the fact that STEM subjects are considered in isolation. These silos have led to different approaches to thinking about how these disciplines should be taught. For example, mathematics has placed a strong emphasis on content-specific learning, while science has tended to encourage inquiry that is facilitated by hands-on practice. However, an emerging consensus is that STEM should be treated as a set of interrelated disciplines that share a common core, rather than as independent entities characterized by fundamentally different ways of thinking. This approach would eliminate the false dichotomy between content and inquiry in favor of a more balanced approach to learning.

There has been coalescence around the idea that cognitive skills are the primary vehicle for improving performance in the STEM disciplines. Yet, it has been suggested that skills within the domain of social cognition may also play a prominent role. Since knowledge is socially transmitted, it could be the case that social interactions around understanding STEM concepts may impact not only the way children think about problems, but also how they might approach problem solving. Therefore, it seems likely that concentrated efforts toward scaffolding social interactions around STEM learning would yield a high rate of return in terms of improving learning and performance in these disciplines.

Coupled with identifying skill sets that lead to a strong foundation in the STEM disciplines is the need to find ways in which the teaching of these skill sets might be enhanced. As such, emerging interactive technologies are being actively considered as viable supplements to current teaching approaches. For example, interactive technologies provide a platform for exposure to, as well as creative problem solving around, STEM concepts. Additionally, interactive technologies may also have the potential to foster social interactions. Examples include learning to work in teams by way of social media websites and interacting with virtual agents. Interestingly, evidence has suggested that positive social interactions may even have the potential to be used to counteract the tendency for girls to opt out of STEM disciplines (Zeldin & Pajares, 2000, Kim, Wei, Xu, Youngah, & Vessela, 2007).

Nevertheless, these lines of reasoning place an undue burden on classrooms for improving STEM education without accounting for other potential influences on learning, like parental beliefs and socio-economic status. Research has shown that parents with lower socio-economic status are more likely to hold the belief that schools are solely responsible for teaching STEM concepts. Moreover, these parents may also lack self-efficacy in one or more of the following domains: (1) understanding the processes of development and learning, (2) realizing that input facilitates learning, and (3) recognizing potential insecurities about their own understanding of STEM concepts. Taken together, these beliefs may lead parents to disengage from the learning process. Therefore, the onus should be on investing in parents as teachers by not only encouraging them to want to share in this responsibility, but by also empowering them to feel more confident in their interactions to teach STEM concepts. Focusing on parental contributions in this way could serve to increase the quantity and quality of parental input, which has been known to positively impact children's learning.

These ideas suggest that researchers, educators, and policy makers would be well served by reconsidering current approaches to STEM education. Better performance outcomes may be achieved by thinking about (1) the skill sets necessary to a strong foundation in STEM learning, including those in the cognitive and social cognitive domains, (2) the ways in which interactive technologies may be used to enhance learning in these disciplines, and (3) the influence of parents on their children's beliefs about and proclivity toward STEM.

Sandra L. Calvert, Ph.D.
Children's Digital Media Center
Georgetown University

Children's Parasocial Relationships for Early Learning of Math Concepts. Characters are ubiquitous in children's media and have the potential to influence learning (Calvert & Richards, 2014). Parasocial relationships are defined as one-way emotionally tinged relationships between a real person and an unknown entity, such as a celebrity, an organization (e.g., a sports team) or an entirely fictional character (Brooks, 1997).

Within the domain of social cognitive development, research has shown that such media characters may serve as teachers for very young children. For example, 21-month old children scored higher on a seriation task after exposure to a lesson by a meaningful character (i.e., Elmo) than those children receiving a lesson from a non-meaningful character named Dodo who was known only to Taiwanese children (Lauricella, Gola & Calvert, 2011). Interestingly, these findings can be extended to fledgling relationships. Specifically, 18 month old children who played with the novel Dodo puppet over a 3 month period later scored higher on a seriation task after viewing the character demonstrate the task on a video than a no exposure control group; children who only viewed the seriation video of DoDo performing the task were not significantly different in their seriation performance from the two other groups Within the 3 month exposure condition, children who played with the DoDo puppet in a nurturing way, an indicator of a parasocial relationship, subsequently performed better on the seriation task than those who nurtured the puppet character less (Gola, Richards, Lauricella, & Calvert, 2013). These findings indicate that early parasocial relationships with characters influence children's STEM learning.

Logical next steps have been to extend this work by enhancing the effect of parasocial relationships on children's learning through interactivity with characters. To this end, Calvert, Richards, and Kent (2014) have used programmable plush toys (e.g., Leap Frog's Scout & Violet) to examine interactivity through character personalization (e.g., having favorite foods and activities or not). Eighteen-month old children were familiarized with either Scout or Violet for three months. Conditions varied whether the character was personalized to them or not. At 21-months, all children were tested on their ability to successfully complete a seriation task after viewing their specific character perform the task on a television screen. Children assigned to a control condition completed the seriation task without previously viewing any video demonstrations. Calvert and colleagues found that children in the personalized condition outperformed those in control condition, but the non-personalized condition did not. Nurturing play behaviors increased significantly over time in the personalized condition, but not in the non-personalized condition. These increases in nurturance within the personalized condition were also linked to improved seriation scores. These findings suggest that interactivity with personalized characters may be used to enhance learning in young children.

Future work will consider the effect of interactive *humanoid* characters on children's learning. Consequently, Calvert and her colleagues are designing an interactive game using Dora from *Dora the Explorer* as the character of interest. Specifically, Dora will be able to interact contingently with a player using parasocial techniques through a Wizard of Oz approach in which an experimenter contingently replies through the character based on what the child does. The goal of the game will be to teach an embedded math concept (i.e., 'add one concept') by having the primary character (Dora) and the player work together to accumulate birthday party goods, despite potential sabotage by another character, Swiper. The assumption, here, is that interactivity with humanoid characters, like Dora, will further increase engagement in a way that will support the learning of an embedded math concept.

Panel 2: Considerations in Creating and Designing Intelligent Agents

"Once you add an interactive element to it, the character can now respond contingently to you and give you specific feedback about whether you're getting a concept or not and that's what we think can really improve STEM learning."

~ Sandra L. Calvert

An intelligent agent can be loosely defined as a persona that is part of a learning environment. As such, intelligent agents may be used to tutor student users in a variety of educational domains by (1) modeling or scaffolding concepts to increase understanding, (2) predicting performance based on this understanding, and (3) using this information to work collaboratively to solve problems. For these agents to be successful, expertise in particular domains must be coupled with a highly nuanced social understanding that can be used to engage the student user. Such engagement has the potential to lead to parasocial relationships – defined as "emotionally tinged relationships [with inaccessible entities like media characters] that parallel real social relationships" (Bond & Calvert, 2014; Horton & Wohl, 1956). Prior research suggests that parasocial relationships can influence learning in young children (Calvert et al., 2014; Gola et al., 2013).

Therefore, researchers across academia, as well as industry, have exhibited increasing interest in designing intelligent agents with the ability to engage student users in parasocial relationships. Yet, designing interfaces that allow intelligent agents to interact dynamically with student users has proven to be a complex task. An emerging consensus is that interfaces should not only capitalize on the social aspect of potential interactivity, but also investigate how this component interacts with emotion and culture in a way that encourages these relationships.

From a social-emotional perspective, intelligent agents must be able to function on three unique levels. Firstly, agents must have the ability to accurately interpret and precisely respond to minute pieces of social information like facial expressions, voice variations, and body posture. Secondly, these pieces of information provide the building blocks for the more sophisticated social responses that drive interactions. Lastly, these basic social interactions can be used to drive richer parasocial relationships. Examples include increased intimacy through self-disclosure or increased empathy through collaboration on mutually shared problems.

In addition to these factors, preliminary evidence has also implicated sociocultural factors, like gender and gender roles, as key to fostering relationships with young children. For example, in their work on personalization, Arroyo and colleagues (personal communication, June 2, 2014) have examined the impact of gender on a student user's problem-solving abilities subsequent to an interaction with an intelligent agent. In this instance, their findings suggest that girls are disproportionately more responsive to gender than are boys. Specifically, girls who interacted with female intelligent agents prior to a problem-solving task demonstrated significant reductions in frustration around problem solving. Additionally, research on gender roles within the gaming industry has found that game preferences fall along gender lines, such that girls overwhelmingly prefer games that promote fairness through malleable rules, while boys prefer those that invoke justice through rule structures that are firm and unwavering.

Ellen A. Wartella, Ph.D.
Center for Media and Human Development
Northwestern University

Parenting in the Age of Digital Technology. At the dawn of the digital age, it is largely unknown how parents engage with their children around newer technologies. In a comprehensive 2012 national survey entitled *'Parenting in the Age of Digital Technology',* Wartella and colleagues found that while television overwhelmingly remained the digital platform of choice, parents and children were also increasing their interactions with other digital platforms, such as computers, tablets and smartphones, though socio-economic status can impede access to these newer technologies. In fact, many parents characterize these activities as being family favorites. The survey also determined that parents generally have four primary concerns about their children: (1) health & safety, (2) school performance, (3) literacy, and (4) concerns around math and science learning.

Taken together, these findings demonstrate that young children have experienced increased access to digital technology that, presumably, has the power to influence their learning in ways that have yet to be determined. Consequently, future lines of research include continuing to determine the myriad ways in which digital platforms can positively or negatively impact STEM learning.

Panel 3: Effective Parent & Teacher Support

"STEM is a very approachable curriculum, [but] so many people have fears – the parents have fears, the teachers have fears – and we're all underestimating young children."

~ Rosemarie Truglio

Currently, preschool classrooms are at a crossroads when it comes to STEM learning. To date, there are no common approaches to curriculum. Moreover, teachers cannot seek guidance from the Common Core, as standards for preschool students have not yet been developed. It is of concern that preschoolers remain outside the auspices of the Common Core, especially since strong foundational knowledge is what sets the stage for later learning.

While this problem is true across educational domains, it is especially important within the STEM disciplines. What do exist are highly variable approaches where children self-select into STEM-based activities that are based largely on hands-on exploration rather than guided inquiry based on the principles of the scientific method. Children's learning would be better served by a strong STEM curriculum that is integrated across disciplines and has the scientific method as its core. While this is often discussed at the policy level, little action has been taken.

Yet, fundamentally, STEM is a very approachable curriculum when the focus is transferred from content within individual silos to integration under the auspices of the scientific process. For example, the Sesame Workshop has demonstrated great success with their STEM curriculum. Using a whole child approach, it focuses on this movement from exploration and toward guided inquiry using the scientific method. While children do not always have the language for specific concepts within given domains, they are able – even in early childhood – to develop language for the processes underlying systematic investigation. As such, this curriculum teaches children how to pose appropriate questions and how to follow a systematic investigative process to find answers to these questions.

Compounding the problem is the fact that a strong background in STEM knowledge is not required for licensure as a preschool teacher. While many teachers have a working knowledge of basic math and science concepts, most have had limited exposure to either technology or engineering. Moreover, the limited scope of activities that teachers are able to provide is based largely on self-guided explorations of nature. Therefore, teachers and students, alike, would benefit from concerted pre-service education efforts aimed at not only empowering teachers around their own STEM understanding, but also helping them to realize that interactive technology has the potential to act as a bridge between classrooms and curricula.

Conclusions

The premise of this workshop was to bring together leading experts in the fields of communications, cognitive and developmental psychology, computer science, human development, and education to engage in meaningful discussions pertaining to the impact of media exposure on children's early learning, especially around the STEM disciplines. These discussions will aid in the further development of the collaborative NSF project entitled *Using Educational DVDs to Enhance Preschoolers' STEM Education* (Grant No. DRL 1252146). In order to achieve this goal, the workshop was divided into three site presentations followed by three panel discussions led by a facilitator. Specifically, the principal collaborators were interested in eliciting conversation around two main points: (1) determining the types of relationships that young children form with on-screen characters and (2) discovering how perceptions about these characters influence what children learn.

Discussions were focused around those tools with the power to enhance learning, especially around STEM concepts. For example, children, parents, and educators have increasing access to televisions, computers, game boxes, tablets, and smartphones. Each of these platforms has the potential to capitalize upon evidence-based curricula, parasocial relationships, and intelligent agency in ways that should serve to positively impact learning through increases in conceptual knowledge, as well as performance through improved test scores. In order to achieve these outcomes, researchers and policy makers must also focus on changing the current narrative around technology and media exposure (i.e., that these tools are 'bad') to one in which they are acknowledged as tools with the potential to augment children's cognitive abilities and educational experiences.

Implications

During the course of this workshop, conversation coalesced around three interrelated topics. First, workshop participants overwhelmingly agreed that the STEM disciplines currently exist in silos and any initial approaches to STEM learning must seek to dismantle these silos in favor of integration across disciplines. Interestingly, a consensus quickly emerged that the common core of these disciplines is the scientific method. Therefore, research on children's learning around STEM topics should focus on ways to move students, parents, and educators toward a focus on scientific inquiry rather than isolated topics or unguided exploration.

Second, there was unanimous agreement that parents and educators need support around interactive technology, mass media, the principles of scientific inquiry (i.e., the scientific method) and STEM concepts, more generally. Parents and teachers often feel insecure about their own knowledge and this insecurity has the potential to trickle down into their interactions with children. An appropriate next step, then, would be to investigate ways in which both parents and teachers can feel empowered in their efforts to guide children's learning.

Third, there was consensus that there was potential to draw upon the social relationships that children develop with media characters as a way to facilitate early STEM learning. These parasocial relationships and interactions will be rapidly evolving in the digital age, as the characters increasingly appear to act in contingent and personalized ways to children's actions.

Ultimately, the need for reform around STEM learning cannot be undersold. In 2012, PISA – Program for International Student Assessment – assessed the reading, mathematics, and science competencies of 510,000 15-year old students from 65 countries and economies. The findings establish that American students under-perform in the domains of mathematics and science - ranking 34th and 24th, respectively. Poor performance in mathematics and science threatens not only the economic prosperity of the United States, but also our standing as a global leader.

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Appendices

Research Sites

Childhood Cognition Lab
University of California, Riverside
Director: Rebekah A. Richert, Ph.D.

The Childhood Cognition Lab explores the interaction between culture and cognitive development. To study this topic, our research focuses on the influence of religion, fantastical thinking, and media exposure on cognitive development. With respect to media exposure on cognitive development, the lab examines how children's understanding of the distinction between fantasy and reality relates to their learning from storybooks, television & DVDs, and interactive media. Research topics include whether or not 12- to 24-month-old children learn from baby videos, the factors that influence whether preschool children will transfer information learned in fantasy stories to real-world situations, and the conditions under which preschool children learn from screen media. Additionally, there is also current research that explores how interactive media may provide a unique kind of scaffolding to learning for children.

Children's Digital Media Center
Georgetown University
Director: Sandra L. Calvert, Ph.D.

The Children's Digital Media Center (CDMC) focuses on the role that educational media play in the lives of children. The CDMD seeks to gain a greater understanding of how interactive digital media affects children's long-term social adjustment, academic achievement, and personal identity. A broader goal is to improve the digital media environment in which children live and learn. Research topics include parasocial relationships (i.e. one-sided, emotionally tinged relationships with media characters), as well as the influence of familiarity on the credibility (i.e. trustworthiness) of media characters. In addition to learning about how young children determine credibility, a secondary goal is to investigate how children interact with and use touchscreen technology.

The Center on Media and Human Development
Northwestern University
Director: Ellen A. Wartella, Ph.D.

The Center on Media and Human Development was created as a center with three primary goals: training, research, and public policy outreach. The center is dedicated to training future researchers to conduct research in the field of human development and media. Research topics include: (1) the ways in which teachers use media technologies in their early childhood classrooms; (2) how parents and teachers interact with their children around and with media technologies including computers, television, and other newer technologies like iPhones and iPads; (3) how parents and teachers differ in their attitudes and opinions about their children's use of, behavior around, and attitudes toward different media technologies both in the United States and abroad; (4) the role that marketing and advertising play on the health of youth in the United States especially with regard to the newer digital technologies children are using; and (5) how digital technologies can be used to improve the lives of children with regard to education, health, and social and emotional development.

Advisory Board

Principal Investigators

Sandra L. Calvert, Ph.D.
Professor, Department of Psychology
Director, Children's Digital Media Center
Georgetown University

Sandra L. Calvert is a professor of psychology at Georgetown University. She is Director of the Children's Digital Media Center. Her research involves the impact of information technologies such as television and computers on children's attention, comprehension, and social behavior. She is a co-principal investigator on the five year multi-site National Science Foundation grant entitled "Collaborative Research: Using Educational DVDs to Enhance Young Children's STEM Education (2013-2018)."

Rebekah A. Richert, Ph.D.
Associate Professor, Department of Psychology
University of California, Riverside

Rebekah A. Richert is an associate professor of psychology at the University of California, Riverside. The overarching themes of her research involve examining how cultural factors and children's developing social cognition influence their understanding of religion, fantasy, and media. She is a co-principal investigator on the five-year multi-site National Science Foundation grant entitled "Collaborative Research: Using Educational DVDs to Enhance Young Children's STEM Education (2013-2018)."

Ellen A. Wartella, Ph.D.
Al-Thani Professor of Communication, School of Communication
Professor, Department of Psychology & the School of Education & Social Policy
Social Policy Director, Center on Media & Human Development
Northwestern University

Ellen Wartella is the Sheikh Hamad bin Khalifa Al-Thani Professor of Communication and professor of psychology, human development and social policy, and medical social sciences at Northwestern University. She is Director of the Center on Media and Human Development and chair of the Department of Communication Studies. She is a leading scholar of the role of media in children's development and serves on a variety of national and international boards and committees on children's issues. She is a co-principal investigator on the five year multi-site National Science Foundation grant entitled "Collaborative Research: Using Educational DVDs to Enhance Young Children's STEM Education (2013-2018)."

Faculty Board Members

Daniel Anderson, Ph.D.
Professor Emeritus, Department of Psychological & Brain Sciences
University of Massachusetts, Amherst

Daniel Anderson is a professor emeritus of psychology at the University of Massachusetts, Amherst. He studies children and television including children's interactions during TV viewing and the impact on cognitive development and education. His current research concerns television and very young children, brain activation during media use, and television viewing and children's diet. He actively advises television producers on the creation of curriculum-based shows for children. He has worked on Sesame Street, Blue's Clues, Dora the Explorer, and Bear in the Big Blue House, among others.

Ivon Arroyo, Ph.D.
Assistant Professor, Department of Social Science & Policy Studies
Worcester Polytechnic Institute

Ivon Arroyo is an assistant professor of social science and policy studies. She studies learning sciences and technologies from three unique perspectives: (1) computer science and engineering (e.g. artificially intelligent tutoring software that models students' knowledge and affective states); (2) education (e.g. understanding how students best learn, develop abstract thought, and perceive mathematics with interactive math learning software, as well as how to support teachers via digital assessment tools); and (3) psychology (e.g. gender differences in the use and benefit of math tutoring software, representations for teaching mathematics, and memory by increasing the speed of retrieval for basic math facts as a means of increasing working memory capacity.

Hilary Barth, Ph.D.
Associate Professor, Department of Psychology & the Program on Neuroscience and Behavior
Co-Director, Cognitive Development Laboratories
Wesleyan University

Hilary Barth is an associate professor of psychology at Wesleyan University. She is also a Co-Director of the Cognitive Development Laboratories. Her research projects explore how young children perceive, learn about, and think about the world. She uses simple (and fun) games to find out more about how kids think about numbers, space, language, and people.

Arthur Baroody, Ph.D.
Professor Emeritus
College of Education
University of Illinois, Urbana-Champaign

Arthur Baroody is a professor emeritus in curriculum and instruction (early childhood and elementary mathematics education) at the University of Illinois at Urbana-Champaign.at the University of Illinois at Urbana-Champaign. His research focuses on the teaching and learning of basic counting, number, and arithmetic concepts and skills by young children and children with learning difficulties.

Kimberly Brenneman, Ph.D.
Assistant Research Professor, National Institute for Early Education Research & the Rutgers Center for Cognitive Science
Rutgers University

Kimberly Brenneman is an assistant research professor at the National Institute for Early Education Research (NIEER) and the Rutgers Center for Cognitive Science. She conducts research on early science and mathematics learning and supports for these in preschool classrooms. Her work at NIEER involves the development and validation of assessments of instructional quality and learning and the design of professional development resources to improve teaching in science and mathematics. Current research initiatives include a project to design and pilot test an innovative preschool professional development approach that integrates high-quality math and science instructional offerings with supports for dual language learners. She also serves as an education advisor for *Sid the Science Kid*, a PBS television series and website that promote exploration, discovery, and science readiness among young children.

Susan Halloway, Ph.D.
Professor, Graduate School of Education
University of California, Berkeley

Susan Halloway is a professor in the Graduate School of Education at the University of California, Berkeley. She is broadly interested in families and schooling within the United States and Japan. Much of her research explores the thoughts, values and expectations of parents and other caregivers regarding the socialization and education of young children. Her work on schooling has focused on the conditions that contribute to low-SES children's engagement in school and their academic achievement. She has also examined the experiences of young children in a variety of early education settings. Recently, she has been engaged in research on the accommodation of families who have a child with a cognitive disability.

Paul Harris, Ph.D.
Victor S. Thomas Professor of Education, Graduate School of Education
Harvard University

Paul Harris is the Victor S. Thomas professor of education in the Harvard Graduate School of Education. He interested in the early development of cognition, emotion, and imagination. His most recent work examines the extent to which children rely on their own firsthand observations or alternatively trust what other people tell them, especially when confronted with a domain of knowledge in which firsthand observation is difficult (e.g. aspects of history, science, and religion that children cannot easily observe for themselves).

Rosemarie Truglio, Ph.D.
Vice President, Education & Research
Sesame Workshop

Rosemarie Truglio is the Sr. Vice President of Education and Research at Sesame Workshop. She is responsible for the development of the interdisciplinary curriculum on which *Sesame Street* is based, and oversees all educational research pertaining to the development of *Sesame Street* content. The results of basic and applied research studies inform both the production and creative decisions for how to enhance both the entertaining and educational components of *Sesame Street*. Dr. Truglio also develops and reviews the content across all *Sesame Street* media platforms and products. Since March, 2009 she also oversees the educational content and research for *The Electric Company* currently on PBS Kids Go!

Workshop Attendees

Evan Barba, Ph.D.
Assistant Professor, Communication, Culture, & Technology
Georgetown University

Evan Barba is an assistant professor of communication, culture, and technology. He is interested in the connection between technology and human thinking in all its various forms across a full spectrum of domains (e.g. design, creativity, learning and education, spatial reasoning, and artificial intelligence). His work is about bridging the gap between the physical and virtual worlds that often extends into material technologies and practices as well.

Kevin Brown, Ph.D.
Senior Research Scientist, NORC
Associate Director, Center for Advancing Research & Communication in STEM
The University of Chicago

Kevin L. Brown is a senior research scientist at NORC at the University of Chicago. He currently serves as Associate Director of NORC's Center for Advancing Research & Communication (ARC) in Science, Technology, Engineering, and Mathematics. His responsibilities at NORC include assessing the technical assistance needs of federally funded education research projects and coordinating the delivery of such assistance. Other duties at the ARC-STEM support center include developing activities to build community among funded projects and disseminating information about REESE projects via the ARC-STEM website and through print publications directed at various stakeholder groups.

Derek Burrill, Ph.D.
Associate Professor, Program on Media & Cultural Studies
University of California, Riverside

Derek Burrill is an associate professor in the Program on Media and Cultural Studies at the University of California, Riverside. His research focuses on digital games, media, gender, and the body. He sits on the editorial boards of Games and Culture and the Journal of Games and Virtual Worlds. He is also an active producer of digital and analog art.

Douglas Clements, Ph.D.
Kennedy Endowed Chair in Early Learning, Morgridge College of Education
Executive Director, Marsico Institute of Early Learning & Literacy
University of Denver

Douglas Clements is a distinguished professor in the Graduate School of Education at the University at Buffalo, The State University of New York. His research interests include mathematics education, curriculum research and scale up, educational technology, and early learning. Dr. Clements was a member of President Bush's National Math Advisory Panel, which advised the President of the United States and the Secretary of Education on means to implement effective mathematics education, including the conduct, evaluation, and effective use of the results of research related to proven-effective and evidence-based mathematics education. Dr. Clements was also a member of the National Research Council's Committee on Early Mathematics.

Alexis R. Lauricella, Ph.D., M.P.P.
Associate Director, Center on Media & Human Development
School of Communication
Northwestern University

Alexis R. Lauricella is Associate Director of the Center on Media and Human Development working with Dr. Ellen Wartella at Northwestern University and a lecturer in the Communication Studies Department. Her research focuses on children's learning from media, parents' and teachers' attitudes toward and use of media with young children, and the effects of food marketing on obesity and health.

Louis-Phillipe Morency, Ph.D.
Research Assistant Professor, Department of Computer Science & Viterbi School of Engineering
Research Scientist, Institute for Creative Technologies
University of Southern California

Louis-Phillipe Morency is a research assistant professor in the Department of Computer Science and the Viterbi School of Engineering at the University of Southern California. His research focuses on the computational study of nonverbal social communication, a multi-disciplinary research topic which overlays the fields of multimodal interaction, computer vision, machine learning, social psychology and artificial intelligence.

Stephanie Reich, Ph.D.
Associate Professor, School of Education
University of California, Irvine

Stephanie Reich is an associate professor of education in the School of Education at the University of California, Irvine. Her research focuses on understanding and improving the social context of children's lives. As such, her empirical investigations center on two contributors to children's socialization: parents and peers. The bulk of her interest examines parent and peer interactions in early childhood with additional research investigating peer interactions in adolescence. Her professional goal is to illuminate how parents and peers affect children's socio-emotional, cognitive, and physical development with the aim of creating interventions to promote physical and mental health and academic success.

Kristina Striegnitz, Ph.D.
Associate Professor, Department of Computer Science
Union College

Kristina Striegnitz is an associate professor in the Department of Computer Science at Union College. Her research interests lie in the domain of computational linguistics. In particular, she is interested in natural language generation, computational semantics and pragmatics, dialog systems and embodied conversational agents.

David Uttal, Ph.D.
Professor, Department of Psychology & the School of Education & Social Policy
Northwestern University

David Uttal is a professor in the Department of Psychology and the School of Education and Social Policy at Northwestern University. He is actively involved in activities that bring together researchers and educators from the cognitive science and physical science communities. Research topics include the understanding and usage of maps and other symbolic representations, learning in museums, and spatial learning in the natural sciences. Dr. Uttal has served as an invited representative of the cognitive science community at conferences that have been attended primarily by chemists, physicists, and geologists. He also serves as a research scientist on an interdisciplinary project to uncover methods of advancing spatial intelligence through education.

Uri Wilensky, Ph.D.
Professor, Departments of Learning Sciences & Computer Science
Director, Center for Connected Learnig & Computer-Based Modeling
Northwestern University

Uri Wilensky is the founder and current director of the Center for Connected Learning and Computer-Based Modeling at Northwestern University. Dr. Wilensky is an associate professor of Learning Sciences and Computer Science, holds an appointment in the cognitive science program and is on the governing board of the Northwestern Institute on Complex Systems. The overarching theme of his educational research has been the creation of a theory and pedagogy of Connected Learning. In particular, he has focused on developing computational tools that enable reconceptualization of traditional math and science disciplines. His most recent projects focus on developing tools that enable users to simulate, explore and make sense of complex systems.

Postdoctoral Scholars

Aubry Alvarez, Ph.D.
Postdoctoral Fellow, Center on Media & Human Development
School of Communication
Northwestern University

Aubry Alvarez is completing a postdoctoral fellowship with Dr. Ellen Wartella at the Center on Media and Human Development. Her primary research interests include the early development of scientific concepts and children’s learning from media.

Ahmed Ibrahim, Ph.D.
Postdoctoral Fellow, Childhood Cognition Lab
Department of Psychology
University of California, Riverside

Ahmed Ibrahim has recently begun a postdoctoral fellowship with Dr. Rebekah Richert in the Childhood Cognition Laboratory. His primary research interests include the development of inquiry, STEM learning, practices of science, technology integration and application, educational research, measurement and evaluation, and program evaluation.

Kate Brunick, Ph.D.
Postdoctoral Fellow, Children's Digital Media Center
Department of Psychology
Georgetown University

Kate Brunick has recently begun a postdoctoral fellowship with Dr. Sandra Calvert in the Children's Media Center. Her research focuses on formal features of children's media, and how low-level parameters of contingency can be manipulated to help children learn from "interactive" television and media characters. Her research goal is to understand how low-level perceptual and cognitive features of media can be effectively used to maximize learning from screen media.

Panel Discussions

Panel 1: STEM Skills & Literacy in Early Childhood

Aubry Alvarez, Northwestern University
Hilary Barth, Wesleyan University
Kevin Brown, University of Chicago
Douglas Clements, University of Denver
Paul Harris, Harvard University
David Uttal, Northwestern University
Rebekah Richert (Facilitator)

Guiding Questions:

(1) Between the ages of 2 and 7, what skills (e.g. cognitive, social-emotional, social-cognitive) are foundational for children's later success in STEM learning and engagement in STEM careers?

(2) How can interactive technologies be used to improve the development of these foundational skills, and how might interactive technologies interfere with the development of these skills?

Panel 2: Considerations in Creating and Designing Intelligent Agents

Ivon Arroyo, Worcester Polytechnic Institute
Evan Barba, Georgetown University
Derek Burrill, U California, Riverside
Louis-Philippe Morency, U Southern California
Kristina Striegnitz, Union College
Uri Wilensky, Northwestern University
Sandra L. Calvert, Facilitator

Guiding Questions:

(1) What definitions of IAs are people using? What do designers mean by the terms that they use? Are these definitions emphasizing or minimizing different aspects of intelligence (ex. social vs. cognitive intelligence)?

(2) What are the most important technical challenges in making IAs respond contingently to child learners? What are the different approaches that designers are taking to address these problems?

(3) What is the role of interface (e.g. speech recognition, facial recognition, motion detection) in designing IAs for children? Which do you think is most important and why?

(4) Are there certain contexts (e.g. game, social collaborative, instructional) in which IAs are most conducive to children's learning?

(5) What is the role of characterization in IA design for children? How can we personalize IAs to maximize engagement and learning by children?

Panel 3: Effective Parent & Teacher Support

Daniel Anderson, U. Massachusetts, Amherst
Kimberly Brenneman, National Institute for Early Education Research
Alexis Lauricella, Northwestern University
Stephanie Reich, U California, Irvine
Rosemarie Truglio, Sesame Workshop
Ellen A. Wartella, Facilitator

Guiding Questions:

(1) What is the curricular approach taken in schools to teach STEM concepts in this age group (i.e. ages 3 to 7)?

(2) What strategies have been used in both television and interactive media (e.g. tablets, apps) to teach STEM concepts to children from 3 to 7? Have they been successful?

(3) What sorts of supports can parents use at home to teach their children STEM concepts? Are there particular challenges parents face in supporting STEM learning at home?

Additional Resources

Journal Articles

Arroyo, I., Burleson, W., Tai, M., Muldner, K., & Woolf, B. P. (2013). Gender Differences in the Use and Benefit of Advanced Learning Technologies for Mathematics. *Journal of Educational Psychology, 105(4),* 957 – 969.

Arroyo, I., Royer, J.M., & Woolfe, B.P. (2011). Using an intelligent tutor and math fluency training to improve math performance. *International Journal of Artificial Intelligence in Education, 21(2),* 135 – 152.

Baylor, A. L. (2011). The design of motivational agents and avatars. *Educational Technology Research and Development*, *59*(2), 291-300.

Baylor, A. L., & Kim, Y. (2005). Simulating instructional roles through pedagogical agents. *International Journal of Artificial Intelligence in Education*, *15*(2), 95-115.

Levine, S. C., Suriyakham, L. W., Rowe, M. L., Huttenlocher, J., & Gunderson, E. A. (2010). What counts in the development of children's number knowledge? *Developmental Psychology, 46(5),* 1309-1313.

Matsuda, N., Yarzebinski, E., Keiser, V., Raizada, R., Cohen, W. W., Stylianides, G. J., & Koedinger, K. R. (2013). Cognitive anatomy of tutor learning: Lessons learned with SimStudent. *Journal of Educational Psychology*, *105*(4), 1152.

Royer, J.M., Tronsky, L.N., Chan, Y., Jackson, S.J., Marchant, H.G. (1999). Math fact retrieval as the cognitive mechanism underlying gender differences in math test performance. *Contemporary Educational Psychology, 24,* 181 – 266.

Book Chapters

Catsambis, S. (2005). The gender gap in mathematics: Merely a step function? In A.M. Gallagher & J.C. Kaufman (Eds.), *Gender Differences in Mathematics* (pp. 220 – 245). Cambridge, UK: Cambridge University Press.

Grawemeyer, B., Johnson, H. Brosnan, M., Ashwin, E., Benton, L. (2012). Developing an embodied pedagogical agent with and for young people with Autism Spectrum Disorder. In S.A. Cerri, W.J. Clancey, G. Papadourakis, & K. Panourgia (Eds.), *Lecture Notes in Computer Science: Vol. 7315. Intelligent Tutoring Systems* (pp. 262 – 267). Chania, Crete, Greece: Springer.

Hartholt, A., Traum, D., Marsella, S. C., Shapiro, A., Stratou, G., Leuski, A., Morency, L.P. & Gratch, J. (2013, January). All together now: Introducing the virtual human toolkit. In R. Aylett, B. Krenn, C. Pelachaud, & H. Shimodaira (Eds.), *Lecture Notes in Computer Science: Vol. 8108. Intelligent Virtual Agents* (pp. 368-381). Berlin, Heidelberg, Germany: Springer.

Lester, J. C., Converse, S. A., Kahler, S. E., Barlow, S. T., Stone, B. A., & Bhogal, R. S. (1997, March). The persona effect: affective impact of animated pedagogical agents. In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems* (pp. 359-366). ACM.

Royer, J.M. & Walles, R. (2007). Influence of motivation, ethnicity, and gender on mathematics performance. In D. Berch and M. Mazzocco (Eds.) *Why is math so hard for some children: The nature and origins of mathematical learning difficulties and disabilities* (pp. 349 – 368). Baltimore, MD: Brookes Publishing.

Conference Proceedings

Finkelstein, S., Yarzebinski, E., Vaughn, C., Ogan, A., & Cassell, J. (2013, July). *The effect of culturally-congruent educational technologies on student achievement.* Paper presented at the Sixteenth International Conference on Artificial Intelligence in Education, Memphis, TN.

Tai, M., Arroyo, I., & Woolfe, B.P. (2013, July). In Roll (Chair). *Teammate relationships improve help-seeking behavior in an intelligent tutoring system*. Symposium conducted at the Sixteenth International Conference on Artificial Intelligence in Education, Memphis, TN.

Virtual Agents

SimStudent: A Computation Model of Learning
Carnegie Mellon University

Noburu Matsuda
Kenneth R. Koedinger
William W. Cohen
Gabriel J. Stylianides, Oxford University

SimStudent is a computational model of human learning. Especially, it is a model of inducing rules by generating explanations of example problem solving steps. SimStudent allows us to study domain-general mechanisms of skill acquisition, which in turn provides us opportunities to advance theories of machine- and human-learning.

SmartBody
University of Southern California

Ari Shapiro
Andrew W. Feng
Stacy C. Marcella

SmartBody is a character animation platform originally developed at the USC Institute for Creative Technologies. SmartBody provides locomotion, steering, object manipulation, lip syncing, gazing, nonverbal behavior and retargeting in real time.

Virtual Human Toolkit
University of Southern California

Arno Hartholt
David Traum
Stacy C. Marsella
Ari Shapiro
Giota Stratou
Anton Leuski
Louis-Phillipe Morency
Jonathan Gratch

The goal of the Virtual Human Toolkit, developed by the University of Southern California Institute for Creative Technologies (ICT), is to make creating virtual humans easier and more accessible, and thus expand the realm of virtual human research and applications.

Relational Agents
Northeastern University

Timothy Bickmore

Relational Agents are computational artifacts designed to build and maintain long-term, social-emotional relationships with their users. Central to the notion of relationship is that it is a persistent construct, spanning multiple interactions, thus Relational Agents are explicitly designed to remember past history and manage future expectations in their interactions with users.

Since face-to-face conversation is the primary context of relationship-building for humans, this work focuses on relational agents as a specialized kind of embodied conversational agent, which are animated humanoid software agents that use speech, gaze, gesture, intonation and other nonverbal modalities to emulate the experience of human face-to-face conversation.