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Measuring with Murray: Touchscreen technology and preschoolers' STEM learning[☆]Fashina Aladé^{*}, Alexis R. Lauricella, Leanne Beaudoin-Ryan, Ellen Wartella

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ABSTRACT

American students rank well below international peers in the disciplines of science, technology, engineering, and mathematics (STEM). Early exposure to STEM-related concepts is critical to later academic achievement. Given the rise of tablet-computer use in early childhood education settings, interactive technology might be one particularly fruitful way of supplementing early STEM education. Using a between-subjects experimental design, we sought to determine whether preschoolers could learn a fundamental math concept (i.e., measurement with non-standard units) from educational technology, and whether interactivity is a crucial component of learning from that technology. Participants who either played an interactive tablet-based game or viewed a non-interactive video demonstrated greater transfer of knowledge than those assigned to a control condition. Interestingly, interactivity contributed to better performance on near transfer tasks, while participants in the non-interactive condition performed better on far transfer tasks. Our findings suggest that, while preschool-aged children can learn early STEM skills from educational technology, interactivity may only further support learning in certain contexts.

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1. Introduction

The domains of science, technology, engineering, and mathematics, known collectively as STEM, have been deemed essential to preparing American children for the U.S. workforce. For example, the U.S. Department of Education has predicted significant increases in the need for STEM-related jobs through 2020 (National Center on Education and the Economy, 2008; US Department of Education, 2010). Comprehensive and innovative educational initiatives within the STEM disciplines are essential in order for America to remain competitive in an increasingly global market.

Yet, in recent years, children in the United States have continued to fall behind their international peers in both math and science. In 2009, the Programme for International Student Assessment (PISA) found that the U.S. ranked 20th of 67 countries in science, well below the international average. In 2012, the U.S. ranking dropped

an additional four spots. In addition to poorer performance on math and science assessments, American students have shown less interest in STEM learning compared to their international peers (President's Council of Advisors on Science and Technology, 2009). In light of these findings, educators and policymakers have turned their focus to increasing STEM engagement and learning across grade levels, especially in early childhood education, where these domains have been historically underrepresented (Ginsburg & Golbeck, 2004).

Although much of the focus on STEM learning has occurred in the K-12 sector (Parette, Quesenberry, & Blum, 2010), some studies have shown that preschool-aged children are not only naturally inclined to explore STEM concepts that are embedded in everyday life (e.g., finding patterns, building structures, and asking how and why questions), but also have the cognitive capacity to link these real world experiences to the underlying scientific concepts, provided that they have appropriate scaffolding from adults (Bonawitz, van Schijndel, Friel, & Schulz, 2012; Brennenman, 2011; Callanan & Oakes, 1992; Carey, 1985).

In recent years, many new technologies have been developed to encourage early engagement with STEM-related concepts and ideas. A search for "science" or "math" in Apple's Kids App Store garners dozens of results. Further, the recent boom in access to

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mobile technology across socioeconomic lines (Rideout, 2013) has led many people to believe that these apps may be a particularly promising way to deliver educational content to young children, that is, if they are well designed and age appropriate (see, for example Hirsh-Pasek et al., 2015). Despite the educational potential of these technologies, very little empirical work has focused on determining the degree to which these types of apps are effective in supporting learning. The present experimental study looks at whether educational technology is, in fact, a potent way to facilitate early STEM learning among preschool-aged children and whether interactivity is a critical component of these technologies.

2. Literature review

2.1. Using technology to support learning

Within the last several decades, a wide array of media technologies has become accessible to young children (Rideout, 2013). Media that have been deemed educational are among the most popular choices for families with children age zero to eight (Rideout, 2014). Fisch (2004) explains that educational media are intended to supplement formal education by exposing children to topics that they might not otherwise encounter and provide compelling experiences that encourage children to spend additional time exploring concepts that they are learning about in school. In fact, research has shown that children benefit when developmentally appropriate content is coupled with entertaining narratives (Anderson, Huston, Schmitt, Linebarger, & Wright, 2001; Dingwall & Aldridge, 2006; Fisch & McCann, 1993; Linebarger, Kosanic, Greenwood, & Doku, 2004; Mares & Woodard, 2005).

Prior work on the role of educational media in early learning has focused on a wide variety of topics, like early literacy (Jennings, Hooker, & Linebarger, 2009; Linebarger et al., 2004), prosocial skill acquisition (Mares & Woodard, 2005), and adoption of healthy behaviors (Borzekowski & Macha, 2010). Few studies have examined the role that mediated experiences play in early STEM learning, however. One exception is the body of research on *Cyberchase*, an animated television show for children ages 8–11, funded by the US Department of Education's Ready to Learn initiative. *Cyberchase* was designed to foster positive attitudes towards math and to teach mathematical reasoning and problem solving. Results from one summative study demonstrated that, compared to non-viewers, children who watched the show once a day over a four-week period showed a significant increase in the quantity and quality of problem solving heuristics in the areas of nonstandard measurement and irregular shapes (Fisch, 2003). However, the work on *Cyberchase* looked mostly at television as the primary learning platform, and the population of interest was older children. There remains a dearth of empirical research on STEM learning from media in the preschool years, especially from newer technology platforms.

2.2. New learning opportunities from interactive technology

As noted, decades worth of research on children's learning from media has focused primarily on the impact of exposure to educational television. More recently, though, there has been a growing sentiment that newly popular interactive technologies,¹ such as

tablets and other touchscreen devices, may offer learning opportunities above and beyond what more traditional platforms, like television, can provide. Indeed, virtually all American households with children now have some sort of touchscreen device, and parents report being more likely to turn to interactive media as an educational tool for their young children than to traditional television (Wartella, Rideout, Lauricella, & Connell, 2014). In light of the prevalence of today's interactive technologies, the American Academy of Pediatrics has relaxed their guidelines advising against screen time for young children (Brown, Shiffrin, & Hill, 2015). Previous guidelines suggested prohibiting screen time for children under 2 and limiting it to 2 h or less for children over 2 (American Academy of Pediatrics, 2013). Under the current AAP policy, it is acknowledged that children are growing up "in a world where 'screen time' is becoming simply 'time,'" and parents are encouraged to use media jointly with their children, model responsible media use, and set limits based on the child's individual needs (Brown et al., 2015).

Despite the growing consensus that new interactive technologies offer inherently different opportunities for children than more traditional platforms, we do not have a thorough understanding of just how these experiences differ. While children and media scholars have begun to investigate the differential effects of interactive platforms such as computers and touchscreens versus traditional video platforms on child learning, the body of research is small and findings are mixed (Lauricella, Pempek, Barr, & Calvert, 2010; Zack, Barr, Gerhardstein, Dickerson, & Meltzoff, 2009; Zack, Gerhardstein, Meltzoff, & Barr, 2013).

Much of the research targeted toward learning from interactive media has focused on literacy outcomes, like story comprehension, by comparing e-books to traditional print books (Jones & Brown, 2011; Krcmar & Cingel, 2014; Lauricella, Barr, & Calvert, 2014). When considered together, the findings are inconclusive. For example, Krcmar and Cingel (2014) found that, in a joint parent-child reading situation, preschool-aged children showed significantly greater story comprehension from a traditional storybook compared to an e-book. However, in a similar study, Lauricella et al. (2014) found no difference in story comprehension between a traditional storybook and an interactive computer storybook. Across these and similar studies, there has not been any clear pattern of evidence demonstrating enhanced literacy learning from digital technology compared to traditional platforms.

Beyond the small body of research on literacy learning from digital media, even less has been done in other areas of education. In contrast to literacy, there is reason to believe that STEM concepts might lend themselves more easily to newer media technology platforms. Science and math skills are typically taught in more interactive ways than literacy by utilizing, for example, experiential methods (Carver, 1996). Thus, the affordances of interactive technologies might be particularly helpful for learning science and math concepts via media. Encouragingly, Huber and colleagues (2016) recently demonstrated that preschool-aged children were able to learn how to complete a problem solving task on a touchscreen device and transfer that learning to a 3D physical context. Problem solving is considered a building block of STEM, so this points to the promise of STEM learning from interactive technologies. While this study compared touchscreen learning to tactile, three-dimensional learning, it did not compare touchscreen learning to learning from more traditional, non-interactive media platforms. The present study seeks to address this gap in our understanding.

¹ We define an interactive technology as one that invites the child to physically manipulate the platform in order to advance the action and is contingent to the child's manipulations. Because tablets and touchscreens are by far the most ubiquitous platforms in American households that meet these criteria, we will focus our discussion on these platforms.

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