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MyTeachingPartner-Math/Science pre-kindergarten curricula and teacher supports: Associations with children's mathematics and science learning☆

Mable B. Kinzie[a,b,*], Jessica Vick Whittaker[b], Amanda P. Williford[b], Jamie DeCoster[b], Patrick McGuire[a,1], Youngju Lee[a,2], Carolyn R. Kilday[b]

[a] *Instructional Technology program, Curry School of Education, University of Virginia, United States*
[b] *Center for Advanced Study of Teaching & Learning, University of Virginia, United States*

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ABSTRACT

MyTeachingPartner-Math/Science (*MTP-MS*) is a system of two curricula (math and science) plus teacher supports designed to improve the quality of instructional interactions in pre-kindergarten classrooms and to scaffold children's development in mathematics and science. The program includes year-long curricula in these domains, and a teacher support system (web-based supports and in-person workshops) designed to foster high-quality curricular implementation. This study examined the impacts of the intervention on the development of mathematics and science skills of 444 children during pre-kindergarten, via school-level random assignment to two intervention conditions (*Basic*: *MTP-M/S* mathematics and science curricula, and *Plus*: *MTP-M*/S mathematics and science curricula plus related teacher support system) and a Business-As-Usual control condition (*BaU*). There were intervention effects for children's knowledge and skills in geometry and measurement as well as number sense and place value: Children in *Plus* classrooms made greater gains in geometry and measurement, compared with those in *BaU* classrooms. Children in *Plus* classrooms also performed better on the number sense and place value assessment than did those in *Basic* or *BaU* classrooms. We describe the implications of these results for supporting the development of children's knowledge and skills in early childhood and for developing and providing teachers with professional development to support these outcomes.

Introduction

Early childhood experiences help develop the foundational mathematics and science skills that allow children to fully engage in creative problem solving, collaboration, and learning (National Association for the Education of Young Children [NAEYC] & National Council of Teachers of Mathematics [NCTM], 2002; National Research Council [NRC], 2006). In fact, early play and experiences that engage children with the real world can lead to significant informal mathematical and scientific understandings (Clements, 2004a; Duschl, Schweingruber, & Shouse, 2007), and help develop the capacity for complex and abstract thought (Bowman, Donovan, & Burns, 2001). This informal knowledge provides the basis for the development of formal knowledge and skills across curricular domains, and particularly in mathematics and science (Bowman et al., 2001). Children's early mathematics and science knowledge and skills predict later school achievement (Claessens & Engel, 2013; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010; National Mathematics Advisory Panel [NMAP], 2008) and are a more significant predictor of later academic success than are early reading skills (Duncan et al., 2007).

This potential is often not achieved, however, as opportunities for learning are missed in the early childhood classroom with important mathematics and science concepts and skills covered in cursory ways (Balfanz, 1999), or as discrete topics without broad

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* Corresponding author at: Instructional Technology Program, Curry School of Education, University of Virginia, P.O. Box 400273, Charlottesville, VA 22904-4273, United States. Tel.: +1 434 924 0835.
E-mail address: kinzie@virginia.edu (M.B. Kinzie).
[1] Now at Department of Curriculum and Instruction, University of Colorado at Colorado Springs, United States.
[2] Now at Department of Education, Korea National University of Education, South Korea.

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linkages and applications (NAEYC & NCTM, 2002; NRC, 2005). Little instructional time is spent on mathematics and science activities. For example, results from the National Center for Early Development and Learning's (NCEDL) national studies (Early et al., 2010) showed that children were exposed to mathematics activities during only 8% of classroom time, and to science activities for only 11% of classroom time, compared to 17% of classroom time in Language and Literacy activities and most of the time observed spent in "no coded learning activity" (44%).

Children from families with lower levels of education and income are at greatest risk for insufficient mathematics and science instruction; child care and early education programs which these children typically attend have been observed to be "of such low quality that learning and development are not enhanced and may even be jeopardized" (Bowman et al., 2001, p. 8). Children from disadvantaged backgrounds demonstrate fewer key mathematical skills at school entry: Results from analyses using the Early Childhood Longitudinal Study – Birth Cohort (ECLS-B) suggest that only 45% of four-year-olds from very poor families are proficient with numbers and shapes, compared to 72% of peers from families at or above the poverty level (NCES, 2009). These children's educational experiences do not serve to close this gap; instead the gap has been observed to widen. Upon Kindergarten entry, children from families with two or more risk factors have shown a seven-point gap in mathematics performance compared to their more advantaged peers; this gap has been seen to widen to 15 points by the conclusion of the third grade (NCES, 2011). Although high-quality learning experiences that build knowledge and skills are critical for all preschoolers, they are even more important for children from disadvantaged backgrounds (NMAP, 2008).

High-quality curricula have been found to support children's mathematics and science learning (Clements & Sarama, 2008; French, 2004; Starkey, Klein, & Wakeley, 2004). However, large-scale studies suggest that even when pre-k teachers are provided with validated curricula, they frequently struggle to implement them with quality and fidelity, likely due to teachers' lack of subject-area content knowledge and confidence (Pianta et al., 2005). This is a problem of particular importance in mathematics and science, where early childhood educators are not well-prepared, receive little professional development (NRC, 2006), and are less confident and less experienced than in other content areas (Copley, 2004; Stipek, 2008). Embedding professional development support within curricular materials can help encourage transfer of desired teaching practices to the classroom. Delivering this professional development support via the Internet can increase scalability and accessibility (NRC, 2007), and therefore may be more likely to make a detectible difference in the practice of a large number of teachers.

In this manuscript, we report the results of a year-long study designed to test the effects of the early childhood mathematics and science curricula, *MyTeachingPartner–Math/Science* (*MTP-M/S*), and an accompanying teacher support system on children's early mathematics and science learning in a sample of preschool children who are at-risk for negative school outcomes. To begin, we provide an overview of the previous research in this area and present the research-based model that supports the design of the *MTP-M/S* curricula and teacher supports. Then, we present our findings and discuss implications for the design and implementation of mathematics and science curricula and companion teacher support system aimed at improving children's mathematics and science knowledge and skills.

Informal development of early mathematics and science skills

Over the past few decades, research has shown that, prior to any formal schooling, young children from ages 0 to 5 develop early informal everyday mathematics skills that are surprisingly broad and complex (Ginsburg, Lee, & Boyd, 2008) and at times, sophisticated (Zur & Gelman, 2004). This informal development typically includes ideas involving basic number sense and operations (Baroody, Lai, & Mix, 2006; Bryant, 1995; Clements & Sarama, 2007a), counting (Baroody, 1992; Frye, Braisby, Lowe, Maroudas, & Nicholls, 1989; Gelman & Gallistel, 1978; Stock, Desoete, & Roeyers, 2009; Wynn, 1990) and geometric thinking (e.g., size, shape, location, and patterns; see Clements, 2004b; Clements, Swaminathan, Hannibal, & Sarama, 1999). Young children also begin to develop basic problem solving and an understating of simple calculation concepts (Levine, Jordan, & Huttenlocher, 1992). This informal mathematics development is not only a natural progression, but a fundamentally important life skill. As Ginsburg, Lee, et al. (2008) suggest, "everyday mathematics is so fundamental and pervasive a feature of the child's cognition that it is hard to see how children could function without it" (p. 3).

Research also indicates that young children can understand scientific concepts such as the life cycle, growth and change, and distinctions between animate and inanimate objects (Backscheider, Shatz, & Gelman, 1993; Inagaki & Hatano, 1996; Springer & Keil, 1991). Moreover, preschool age children are capable of reasoning scientifically. For instance, they are able to infer how misleading evidence can lead to forming a false belief (Ruffman, Olson, Ash, & Keen, 1993). More recent research has suggested that by the age of six, children can differentiate between hypotheses and evidence (Ruffman, Perner, Olson, & Doherty, 1993; Sodian, Zaitchik, & Carey, 1991), which is earlier than prior research had suggested (Kuhn, 1989; Piaget & Inhelder, 1969). Thus, young children are not only capable of engaging in mathematics and science thinking and learning, but they also possess substantial informal understandings that can serve as the basis for formal mathematics and science knowledge and skills.

MyTeachingPartner-Math and Science curricula and teacher support system

MyTeachingPartner-Math/Science (MTP-M/S) curricula were designed in response to the need for high-quality pre-k mathematics and science curricula. Their design was responsive to the foci above, informed by the research in early mathematics (Clements, 2004a; Ginsburg, Lee, et al., 2008; Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Sarama & Clements, 2003) and science education (Duschl et al., 2007; French, 2004; Gelman & Brenneman, 2004; National Research Council [NRC], 2006), and in alignment with national and state standards. The curricula possess similar activity designs and forms of teacher supports and also reference concepts reflective of both mathematics and science wherever possible, but were designed to also stand alone. Each curriculum includes two activities (each activity 15–20 min in length) every week, for 33 weeks across the school year. Weekly "center time" options enable the teacher to revisit specific mathematics and science activities with small numbers of purposefully selected students. Table 1 provides an overview of the curricular activity design, the activity domains and sub-domains addressed, and the numbers of activities corresponding to each.

Table 1 also describes the *MTP-M/S* Teacher Support System to encourage teachers' curricular implementation fidelity – both their adherence to the curricula as designed and the quality of their related interactions with students in the classroom – as well as support the development of teachers' pedagogical and content knowledge. Some of these supports are embedded in the curricula and provided to all teachers (the "within activity supports" are part of the *MTP-M/S Basic* curricular package), and many others are separately delivered as part of *MTP-M/S Plus* (curricula plus