Abstract Title Page

Title:

Development of Curricula, Teacher Supports, and Assessments for Pre-Kindergarten Mathematics and Science

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Abstract Body

Background/context:

Need for Early Childhood Curricula in Mathematics and Science. Informal mathematical knowledge undergoes considerable development during the preschool years (Baroody, 1992; Beilin & Klein, 1982; Cooper, 1984; Mix, 2002; Newcombe & Huttenlocher, 2000; Starkey & Cooper, 1995; Wynn, 1990; Zur & Gelman, 2004), and lays the foundation for the development of formal mathematical knowledge and skill in elementary school (Geary, 1994; Ginsburg, 1998). The development of this knowledge can be fairly easily nurtured through both play and instruction. This is particularly important for children who live in poverty, as they have been shown to experience considerable difficulty in mathematics and early intervention programs can address equity issues and narrow the performance gap (Clements, 2001).

Young children also develop substantial informal science knowledge, by actively engaging with their environments to understand observed phenomena and develop essential process skills (Eshach & Fried, 2005; Gallenstein, 2003; Lind, 1999; Platz, 2004). These skills, along with conceptual understandings and inquiry strategies, begin to develop as early as infancy, with the sophistication of children's competency developing with age (Klein, 1998; Lind, 1999; Meyer, Wardrop, & Hastings, 1992; Piaget & Inhelder, 2000). Environmental effects are important—the lack of needed stimuli may result in a child's development not reaching its full potential (Hadzigeorgiou, 2002).

Basis for Curricular Design. The *MTP-Math/Science* curricula specifically target the teaching and learning of children at risk of early school failure, a population for whom achievement gaps in mathematics and science are visible even in Pre-K years. *MTP-Math* is based on Focal Areas defined by the NCTM (2006) for Pre-K through the 8th grade and developmental trajectories for Mathematics from Pre-K to grade two advanced by Clements (2004), and further focused through a review of state Pre-Kindergarten standards. The domains of *MTP-Math* include: Number, Operations, Geometry, and Measurement. Within the Science domain, the AAAS K-12 Science Benchmarks (1993) identified conceptual and skill domains targeted for Kindergarten and beyond; state standards helped refine our curricular focus for Pre-K within these domains. The *MTP-Science* domains include the Life, Earth, and Physical sciences.

To provide authentic points of inquiry, our year-long curricular trajectories reflect seasonal changes; we used these trajectories to help extend children's thinking across the year (*spiraling)*. *MTP-Math/Science* offers a variety of inquiry-based activities, with ample opportunities for children to observe, predict, collect, analyze and communicate both their processes and results. We emphasize a balanced integration of student-centered, highly-contextualized and meaningful interactions with teacher-directed, scaffolded target exposures to key concepts. The work of Ginsburg (Ginsburg & Golbeck, 2004) has been influential, as we emphasize opportunities to encourage children's thinking and model and elicit mathematics and science language to express that thinking. Children are encouraged to Engage, Investigate, Discuss, and Extend, a modification of the 5E Model (Bybee, et al., 2006). We use children's literature to anchor investigations, providing background context and comfortable entry points, further supporting the development of literacy and language. Design of *MTP-Math/Science* is illustrated in Fig. 1.

Iterative Curricular Development. An iterative *rapid-prototyping* approach helps designers ensure that products are effective and engaging. Our activity design began with creative brainstorming and continued to development of early prototypes that were repeatedly revised, evaluated by teachers and tried out in classrooms before they were "finished." Prior opportunities to learn help determine what is developmentally appropriate (National Research Council, 2007), and our year-one classroom observations (in three pilot classrooms) suggested the importance of *multiple opportunities for students to engage* with targeted concepts. These opportunities are now achieved using center time, strengthening the *spiral bonds* between activities throughout the year. We also observed teachers' tendency to focus on the *doing* of activities rather than on encouraging students' *thinking* about them. In response, we have placed additional curricular emphasis on opportunities for modeling language and eliciting thought.

The Need for Pre-Kindergarten Teacher Development in Mathematics and Science. Even when offered validated curricula, teachers in Pre-K programs are highly likely to *not* implement them with high quality or fidelity, largely as a function of their lack of content knowledge and lack of confidence, in addition to general struggles to conduct instruction effectively (Pianta et al, in press). The preschool teaching force has been "generally characterized by inadequate preparation and offered inadequate ongoing professional development and these teachers generally have few years of experience because of high turnover rates" (National Research Council [NRC], 2005, p 16). Teachers in early childhood programs lack confidence in their knowledge of science and science education pedagogy (Fensham, 1991; Garbett, 2003). The same tends to be true in mathematics: most preschool teachers who do not have appropriate and effective training in mathematics do not value mathematics as a priority for young children, and they lack confidence in their own abilities to teach mathematics (Baroody & Coslick, 1998). Well-designed professional development experiences have enhanced teachers' learning of concepts in mathematics and science and their teaching practices (Katz, 1999) and have lead to improved preschool program quality (National Research Council [NRC], 2001).

Teacher Supports and the *MTP* Logic Model. In their review of primary prevention programs for mental disorders, Greenberg and colleagues (Greenberg, Domitrovich & Bumbarger, 2001) found a significant relationship between quality of implementation and classroom outcomes. Large-scale observations conducted for the Multi-state Study of Pre-kindergarten and the Statewide Early Education Programs (SWEEP; LoCasale-Crouch et al., 2007; Mashburn et al., 2007; Pianta, Howes, Early, Clifford, Bryant, & Burchinal, 2003) indicate that variation in instructional and emotional support quality were directly related to growth in children's achievement test scores and social behavior ratings. These findings underline the importance of professional development emphasizing and assessing both high fidelity and high quality.

In our earlier research with the *MTP* model to support language and literacy (Pianta, Mashburn, Luckner, Myers, & Kilday, 2008), the *MTP* teacher professional development program improved the quality of classroom interactions that Pre-K students experience, which in turn, promoted children's development of language and literacy skills. Targeting teachers' interactions with students as the focus of professional development and training may be particularly beneficial because these interactions are the proximal mechanism responsible for effects on children's early experiences. This forms the basis of the logic model for *MTP-Math/Science*, depicted in Figure 2.

Purpose/objective/research question/focus of study:

In year two of our project, we are applying the *MTP* model to the design and development of embedded on-line teacher supports emphasizing high quality classroom interactions, high fidelity implementations, and continuing to iteratively evaluate the curricula. Our development focus is:

- How might we best support instructional practice with on-line, embedded teacher supports?

We are also considering the following research questions:

- Are classroom quality and curricular fidelity positively correlated with pre/post gains in children's mathematics learning? …with end-of year scores in science?
- Are there correlations between quality and fidelity?

As the amount of teacher exposure to the curricula and embedded math and science concepts increases, do teaching quality and fidelity also increase?

Setting & Population:

We are currently implementing the *MTP-Math/Science* curricula in eight Pre-K classrooms from a state-wide initiative providing publicly-funded Pre-Kindergarten to children who have one or more risk factors for later school failure (poverty, second language learners, or health or developmental problems). In our previous research with such classrooms (Pianta, et al., 2008), annual family income was less than $15,000 for 31% of the families and between $15-25,000 for another 25% of families. A high school degree or less was reported by 42% of mothers. Among teachers, 95% were female and the majority reported their race/ethnicity as Caucasian (72%), 24% as African American, and 4% multi-racial. In terms of education, 66% had a bachelor's degree and 35% had advanced degrees, while 85% were specifically certified to teach 4-year-old children. Teachers reported an average of 16 years teaching experience (range = 1 to 43 years).

Intervention/Program/Practice:

Teachers implement *MTP-Math/Science* curricular activities four times/week (two math and two science). Activities range from 10-25 minutes in length; the majority are facilitated in small group settings (six to eight students) while the remaining activities take place in whole group format. In addition, we provide teachers with supplemental center time activities intended to help students re-visit key concepts or ideas, and provide for additional exploration or practice. Teachers are also being exposed to on-line teacher supports during this year of the project. These supports include video demonstrations of high quality, high fidelity teaching practice; video demonstrations of underlying math and science concept knowledge; and interactive "Quality Teaching Challenges," among other elements. Most of these are embedded within the curricula, to be encountered in the context of teaching practice.

Research Design:

Our current research is quasi-experimental, allowing implementation of our curricula and consideration of the relationships between variables .

Data Collection and Analysis:

<u>Development Analyses.</u> We are conducting video observations of all activities across the year. To help us ensure that a range of teaching practice is being observed, but to control the observation time required, we have separated teachers into high/low quality groups, based on administration of the Classroom Assessment Scoring System (CLASS; Pianta, La Paro, and

Hamre, 2008). To evaluate each activity, we randomly select a video from one teacher in the high quality group and one from the low quality group (selection without replacement until all teachers have been observed). We also obtain useful information from periodic focus groups, the end-of-year teacher survey, and end-of-year teacher interviews.

Participant Characteristics. Participants will be described through data obtained from the Fall Teacher Survey (including demographics, math/science preparation, attitudes, beliefs, and use of technology) and from the Fall Family Survey (ethnicity, mother's education, and family income).

Child Outcomes-Mathematics. Child outcomes in mathematics will be determined through scores on two measures. The Test of Early Mathematic Ability – 3rd Edition (TEMA-3; Ginsburg & Baroody, 2003) reflects a child's knowledge of both formal and informal mathematic abilities, focusing on the domains of counting, one-to-one correspondence, numeral recognition, number facts, calculation, and understanding of concepts. The Early Mathematics Assessment – Geometry (EMA-G; Clements & Sarama, 2008) covers geometry and measurement, including shape identification, matching, and production, pattern identification, reproduction and extension, length and weight. We are using an abbreviated version of the EMA-G.

Child Outcomes-Science. There are no currently available, valid, reliable assessments focused on pre-K students' understanding of specific science content. Some assessments of general cognitive abilities (e.g., Woodcock-Johnson) or vocabulary (e.g., Peabody Picture Vocabulary Test) include a limited set of scientific concepts. However, these assessments fail to include important elements such as making observations and conducting investigations. We are currently developing a Pre-K science assessment to indicate children's understanding as a function of the *MTP-Science* curriculum and to measure children's ability to integrate and generalize those concepts. The science assessment will be comprised of two components: life sciences and physical/earth sciences. Assessment items were based on curricular objectives and tasks adapted from a variety of published studies. In accordance with the National Science Education Standards, each concept is assessed in two or more ways, for example through both identification and verbal narrative tasks. Multiple methods of assessment provide converging evidence regarding children's understanding of specific concepts, increasing reliability. This will also help reduce the possibility of drawing erroneous conclusions on the basis of individual characteristics (e.g., verbal ability, shyness). The science measures are undergoing two cycles of pilot testing and revision. The resulting measures will be employed in an end-of-year assessment to children in our participating classrooms, in addition to those from two control classrooms.

Child Outcomes Vocabulary. The Peabody Picture Vocabulary Test –III (PPVT-3; Dunn & Dunn, 1997) is a test of receptive vocabulary for ages two years, six months up to adulthood. For each word provided, respondents are asked to select a corresponding picture from a set of four. The receptive language data will be used as a covariate when considering other child outcomes.

Teacher Ratings: Mathematics and Science. Teachers will rate children's mathematics skills, using the Academic Rating Scale (ARS) for Mathematics (developed for the ECLS-K, National Center for Education Statistics, 2002), including five additional items to address missing aspects of geometry and operations. For teacher rating of science knowledge and skills, three items have been drawn from the ARS General Knowledge (also developed for the ECLS-K); additional items will address missing concepts and skills.

Implementation Outcomes: Dosage. Teachers will complete monthly questionnaires indicating which curricular activities they have completed; these will be cross-checked against the videotapes they submit (teachers videotape all curricular activities). Teachers will indicate via end-of-year survey the time they spent facilitating curricular activities each week.

Implementation Outcomes: Fidelity. Based on the design theories undergirding our curricular design, and drawing on previous measures of fidelity in early childhood curricula (Hamre & Pianta; Ertle & Ginsburg, 2006; Clements & Sarama, *in press*), we developed a rating scale for implementation fidelity. Primary constructs measured include: Activity Completion, Materials & Environment, Teacher's Instruction, Ensuring Engagement, Content Coverage, and Supporting Cognition & Language. Scale items address classroom conditions as well as teacher and child behaviors. This assessment has been iteratively tested and revised.

Implementation Outcomes: Quality. The Classroom Assessment Scoring System (CLASS) for Pre-Kindergarten was developed by Pianta, La Paro, and Hamre (2008) to examine the interactions between children and adults in classrooms that lead to better child outcomes. The CLASS is comprised of three domains: emotional support, classroom organization, and instructional support, each of which is split into three to four dimensions. Each dimension is scored based on a range of behavioral indicators. For both Fidelity and Quality, we will randomly select two videotapes/month from each teacher (excluding the first and last month). If activities are longer than 30 minutes, the activity will be divided into two segments, to be separately coded. Coders will be randomly assign to classrooms and to videotapes.

Analyses: Quality and Fidelity, Child Outcomes, and Change Over Time. Children's gains in mathematics and their end-of-year scores for science will be plotted against both classroom quality and curricular fidelity. Correlational analyses will help identify relationships between quality and fidelity, and between teacher/classroom characteristics and quality and fidelity. We will also investigate changes in quality and fidelity across the year. here

Findings/Results & Conclusions:

Baseline data for children's Mathematics and Vocabulary performance are included in Table 1 (Appendix B). Eight students from each classroom were assessed using the TEMA-3, PPVT-3 and the abbreviated version of the EMA-G. The sample was comprised of 27 boys and 37 girls (42-54 months) all of whom will be eligible for kindergarten in the 2009-2010 school year. Additionally, two classrooms, similar in demographics and age of the students, were recruited to function as control classrooms. Eight children were tested in each of these classrooms as well. All data is presented in terms of the raw scores achieved. For the TEMA-3, the average number of problem solved correctly was 7 (SD = 5.62). For the EMA-G the average number of correctly answered problems was 24 (SD = 8.08). For the PPVT-3, the average number of pictures correctly identified was 64 (SD = 21.26).

Other data from year two are still being collected and analyzed. We will report on the evaluation of our curricula, associated teacher supports, and science assessment development. We will also provide preliminary findings related to classroom quality and curricular fidelity. Finally, we will describe how year-two findings will inform the design of our year-three field trial.

Appendices

Appendix A. References

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Appendix B. Tables and Figures

Table 1

Descriptive Statistics for Fall Administration of TEMA, EMA, and PPVT

	TEMA	EMA	PPVT
Mean	7.00	24.00	64.42
Standard Deviation	5.63	8.08	21.26
Range	19	30	77
Minimum	0	7	26
Maximum	19	37	103

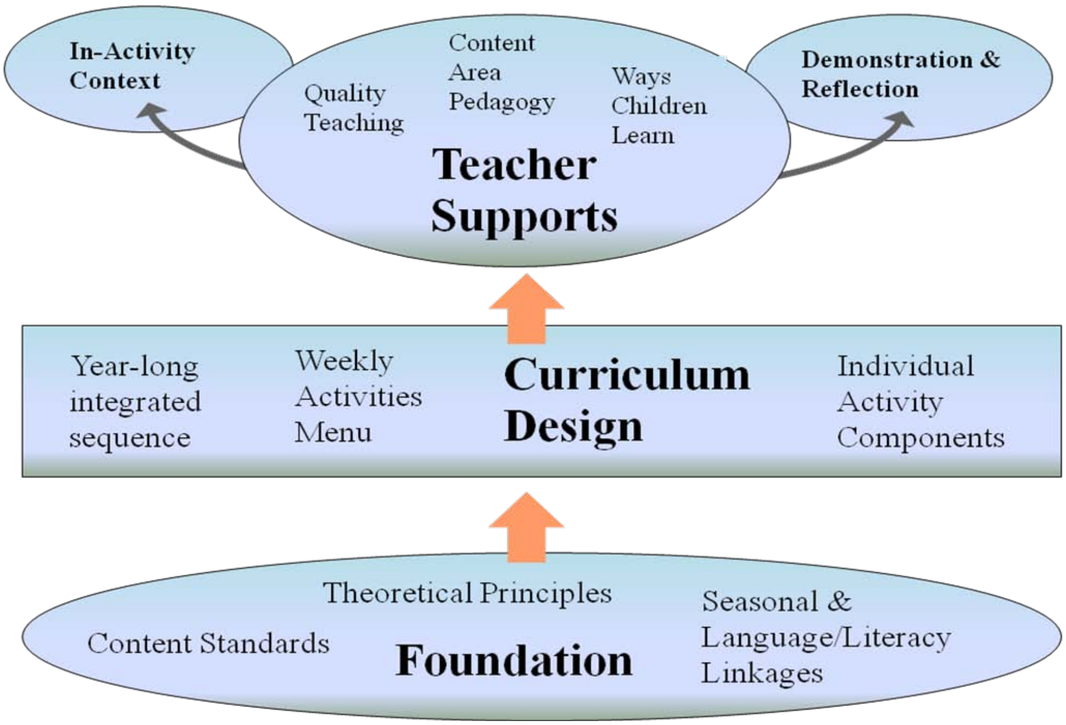

Figure 1. Foundations of *MTP-Math//Science* Design

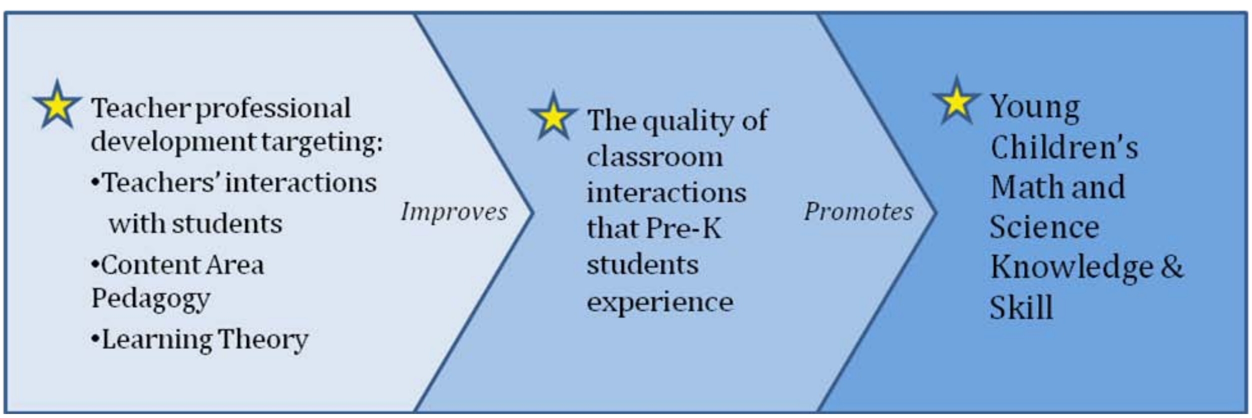

Figure 2. *MTP-Math//Science* Logic Model