Abstract Title: NebraskaMATH: Primarily Math Research Design

MSP Project Name: NebraskaMATH

Author(s): Wendy Smith, Traci Kutaka, Carolyn Edwards, Ruth Heaton, Walter Stroup

Presenter(s): Wendy Smith, Ruth Heaton

120 word summary:

NebraskaMATH: Primarily Math is a three-tiered initiative including a K-3 math specialist graduate certificate program; support for teachers as they return to the classroom as math coaches or classroom math teachers; and a research project studying the impact of Primarily Math on teacher practices, attitudes, and leadership, and student achievement and dispositions. The design includes participants, controls, and teachers in buildings with new math coaches. We describe the study's design and present initial findings related to student success as measured through the Test of Early Mathematical Ability 3rd Edition. Based on our initial data collection and analysis, we discuss pros and cons of the current research design and describe the initial and ongoing roles STEM faculty play within the research.

Section 1: **Questions for dialogue at the MSP LNC**.

- How can MSPs design research studies to measure the impact of their professional development on student success?
- How can STEM faculty be involved in research design and analysis related to student success?

Section 2: **Conceptual framework**.

Context of the work within the STEM education literature and NebraskaMATH

NebraskaMATH funds three programs, (1) Primarily Math, an initiative for K-3 teachers, (2) Nebraska Algebra, an initiative for Algebra I teachers, and (3) New Teacher Network, an initiative for new secondary teachers of mathematics. Primarily Math is a three-tiered initiative that includes an investment in K-3 teacher education through a graduate certificate program; support for these teachers as they return to the classroom as math coaches or classroom math teachers; and a research project to study the impact of Primarily Math on teacher practices, attitudes, and leadership, and student achievement and dispositions. The fundamental goal for all three NebraskaMATH programs is to increase the levels of Nebraska student success in mathematics, especially for struggling students. When considering Primarily Math as a vehicle to support increased student success, the objectives are to: enhance mathematical and pedagogical knowledge among K-3 teachers; enrich teachers' understanding of cognitive development and everyday mathematics at the foundation of mathematical thinking of birth to age 8 children; enable K-3 teachers to transfer and apply knowledge of mathematics and child development into math lesson planning and mathematical learning experiences across the curriculum, with particular attention to at-risk children; establish communities of practice that promote teacher leadership in K-3 mathematics within schools, districts, and ESUs; and conduct research that informs districts and the mathematics education community regarding the effectiveness of various methods for teaching K-3 mathematics. We believe these objectives are the keys to leveraging increases in K-3 student achievement in mathematics. Improving early childhood mathematics education has been recognized as critical to addressing the problems of U.S. children's weak mathematical performance, particularly the achievement disparities of poor and minority children (Ginsburg, Lee, & Boyd, 2008), and elementary math specialists have been identified as a hopeful solution (Reys & Fennell, 2003).

Primarily Math responds to two critical issues influencing student success and the teaching of math at the K-3 levels: teachers' poor math preparation and fear and avoidance (Ginsburg, Lee, & Boyd, 2008). To achieve student success, primary grade teachers must balance teacher-guided instruction with child-guided experiences and teach math in a concept-rich way that connects with other academic areas, particularly literacy and science (Copley, 1999; Clements & Sarama, 2007; De Corte & Verschaffel, 2006; National Association for the Education of Young Children and National Council of Teachers of Mathematics, 2002). However, few K-3 teachers are equipped to do so successfully. Teaching math skills and concepts in a way that matches the developmental and learning needs of younger children and helps them *mathematize* (i.e., to interpret their experiences in explicitly mathematical forms) is complex (Ginsberg, Lee, & Boyd, 2008; Kilpatrick, Swafford, & Findell, 2001). With this in mind, key ideas driving the specialist program include the creation of strong mathematician/mathematics educator/school partnerships; mathematics courses that are rigorous and useful to K-3 teachers; linking mathematics instruction with effective pedagogy across the range of K-3 classroom experiences (e.g., math-focused lessons, math integrated into other subject matter, informal child-led experiences involving games, exploration, and problem-solving, and math learning connections across school and home contexts); promotion of skills and dispositions to conduct inquiry into mathematics teaching and learning through communities of practice (Sheridan et al., 2009); and providing instruction and apprenticeship in the specialized role of math coach (West & Staub, 2003). As recommended by *The Mathematical Education of Teachers* (CBMS, 2001), Primarily Math specialist courses aim to "develop the habits of mind of a mathematical thinker and demonstrate flexible, interactive styles of teaching" (CBMS, p. 8) and in turn we hope teachers will develop comparable mathematical habits in young children.

Based on the needs of the core partner districts, teachers with the Math K-3 Specialist certificate move into mathematics specialist roles (building mathematics coaches or math-intensive teachers teaching more than one mathematics course), or remain general classroom teachers. The case for mathematics subject-matter specialists at the elementary school level has been made by Reys and Fennell (2003), while recent findings from Ohio suggest math coaches lead to improvements in student math proficiency (Findel, Brosnan, & Erchick, 2008). In each of these leadership roles, specialists network with peers and administrators to facilitate improvement in mathematics education. They are supported through study groups of 6-12 members, organized by faculty in collaboration with system administrators and supported by school districts.

Claims examined

The overall goal of the Primarily Math research study is to study Primarily Math participants and non-participants and their students to examine what happens to teaching practice, teacher leadership, and student learning, achievement, and competence beliefs and values.

Children's beliefs about competency are not always an accurate reflection of real capacities, but this may be appropriate when we consider children's developmental status. Upon entry to kindergarten and primary school, children tend to be unrealistically optimistic about how they evaluate their performance (Chaffel, 2003). However, as they progress through school, children demonstrate a linear decrease in their beliefs about how well they have mastered tasks or acquired skills (Marsh, Craven, & Debus, 1991).

One of the five strands of mathematical proficiency includes a productive disposition, composed of healthy beliefs that can fortify persistence, creativity, and efficacy during problem-solving as well as a "habitual inclination to see mathematics as sensible, useful, and worthwhile" (Kilpatrick, Swafford, &

Findell, 2001, p. 5). However, little is known about its cultivation in the earliest years of schooling. Early childhood may be a period when educators can intervene to help students establish productive dispositions or reverse unproductive mathematics-related beliefs.

In Primarily Math, based on the first year of data collection, only a minority of students reported low competence beliefs as they rated themselves on their ability to do and learn math. However, we begin to see an association between competence beliefs and achievement, even in the early grades, K-3. The sub-group of students with low-competency beliefs scored significantly lower on a standardized measure of mathematical ability than peers with high-competency beliefs. This mean score difference increased in magnitude with age. Nevertheless, most of the students in this sample, even those who reported low competence beliefs, received average or above average Math Ability Scores on the TEMA-3.

Section 3: **Explanatory framework**.

Research Design

The Primarily Math research study is designed to focus on the following main research questions:

1) How do teachers translate the mathematical attitudes, knowledge, and habits of mind emphasized during the Primarily Math Certification Program into measurable changes in teaching practice?
2) How do new structures of leadership in mathematics teaching impact the culture of schools?
3) To what extent does the intervention translate into measurable improvement in students' beliefs and achievement in the areas of math and reading?

While only the third question directly addresses student success (measured as surveyed competence beliefs and mathematics achievement on an individualized achievement test), changes in teaching practice and school cultures need to occur in order to realize the desired increases in levels of student success. Teacher data are collected from all participating teachers (and control group participants). Because of the lack of a state math test (until spring 2011), we chose to focus our collection of student data, based on the use of the TEMA-3, with young children in our two largest partner districts.

Since prior work of some of the NebraskaMATH PIs suggested projects like Primarily Math, who repeat professional development offerings over multiple years of funding, could see a significant "cohort effect" when new groups of teachers are admitted to professional development programs each year (with the strongest teachers applying in the first year), we decided to solicit applications for the first three cohorts of Primarily Math all in year 1, and then randomly assign accepted teachers to cohorts. Our research group, which includes STEM, Education, and Developmental Psychology professors and graduate students, and K-12 representatives from partner districts, decided that random assignment would be done at the school level. Division of schools into cohorts was done so the "profile" of schools in each cohort in a district is similar in equal distribution of the range of possible socio-economic statuses of schools. There were initially two kinds of control teachers in the research study: participant (P Controls) and non-participant (NP Controls). P Controls have been admitted to Primarily Math, but have not yet begun their coursework. NP Controls come from nonparticipating schools. Including teachers who do not plan to participate or are not interested in participating is critical because they must be assumed to bring *potentially* different pre-dispositions regarding K-3 math. Such differences could show up in attitudes and student progress. In Year 2 of Primarily Math, a third group of participants was purposefully recruited: selected K-3 teachers in buildings with Primarily Math coaches. Since coaches first moved into buildings in Year 2, in cooperation with school district partners, it was not possible in Year 1 to identify which buildings might later have coaches.

In Year 2, one of the two smaller partner districts had recruited additional participants, and thus in partnership with the school district, we decided to expand our study of student success to this district as well. In this district, we first selected three types of schools: those with a Primarily Math coach (from cohort 1), those with a Primarily Math participant (from cohort 2), and those with no participants. Teachers were then selected from each building, so the participants in the research study matched the research participants already recruited.

The mixed methods design of Primarily Math benefitted greatly from STEM faculty participation, particularly the Co-PI who is a statistician. STEM faculty in collaboration with faculty in teacher education and early childhood education have been involved in the design and implementation of the intervention. The data collected to study the impact of the intervention include:

- Three annual surveys from all Primarily Math teachers, as well as the control groups: Survey of Teaching Practices, Mathematics Attitude Inventory, and Mathematical Knowledge for Teaching;
- Teacher Network Survey of all teachers and administrators in all elementary buildings in our four core partner districts (administered three times across 5 years);
- Child measures from classrooms participating in research study across three school districts: Test of Early Mathematical Abilities, 3rd Edition, and Survey of Child Beliefs and Competence Values;
- Child interviews of a small subset of those surveyed to further explore children's beliefs and competence values;
- Adult interviews of a small subset of those in one district who took the teacher network survey to further understand the content of teacher advice networks and how school cultures facilitate or hinder actions among participants; and
- Qualitative observations and interviews utilizing a paired case study design (each "pair" is a teacher and several of her or his students) to further examine teaching practices and what is happening in classrooms following the intervention.

Additionally, once a state math test is implemented in Spring 2011, we will collect elementary achievement data from participating districts. We expect these data will help us map out student and teacher trajectories, as well as connections among teacher and student trajectories. By collecting data from classrooms in buildings with classroom teacher participants, math intensive teacher participants, math coach participants, as well as schools with no Primarily Math participants, we hope to be able to then draw conclusions about the effects of various math specialist roles on student success.

Key Insights

- Extensive planning and a carefully designed research study are necessary to support later claims about the impact of professional development on student success. Rationales for particular decisions and revisions related to the research design must also be documented.
- A carefully planned and articulated intervention is important to the research study. Documenting revisions made to the intervention is also important.
- Recruiting multiple cohorts in the first year and recruiting NP-controls and coach building participants were possible due to including school districts in advance planning, as well as our experiences with previous research projects.
- By recruiting cohorts in advance, we were able to collect baseline data from participants (except the first cohort) and thus allow teachers to serve as their own controls.
- By focusing on the building level (to assign teachers to cohorts and to match controls) we set ourselves up to look for building effects of mathematics specialists. This is a focus that evolved from the time our proposal was submitted (when we were focused on teachers as our "unit") as we had further conversations with STEM faculty who wanted to try to identify effects of mathematics specialists on buildings. This seems like an obvious point now—to focus on the building level—but represented a shift of thinking for our project.
- Talking with Mathematics faculty helped determine some of the research questions: what is it mathematicians would be interested in learning from a program like Primarily Math?

- Involving Statisticians in the research design was incredibly beneficial. Statisticians helped us to consider new ways to analyze complex and messy data, and to think about how to shape our research design to best anticipate and make use of the unpredictable nature of doing research in real schools with real teachers and students.
- As we collect more data from teachers and students, we will begin to connect teacher and child measures of mathematical knowledge/achievement as well as attitudes and beliefs; these are two perspectives on knowledge and beliefs that are frequently studied but infrequently linked within the same study.
- We do not expect to see coaching effects in the first year in which coaches are in buildings. Teaching practices change slowly, and it takes time to see changes in teaching practice impact student achievement in measurable ways. Based on Campbell's work (e.g., Campbell & Malkus, 2009), we anticipate the first possible coaching effects in the third year of coaches in buildings (thus in years 4 and 5 of the grant).
- It is important to acknowledge and understand the perspective of the child; particularly insightful is to do so through direct dialogue and engagement in their classroom as active observers. Student definitions and reference points acquired during child-interviews proved not only to be an important starting point for data analysis, but also provided a context for how math is used and thought about. Given the great variability in how children define math and its place in their world, researchers should take great care in how they operationalize phenomena related to children. Imposing an adult interpretation of child experiences may lead to specious description of a child's mind and less effective mathematics-related interactions and instructional efforts. Findings from a pilot study doing qualitative interviews with a small number of children have prompted us to design a larger qualitative study on children's attitudes and beliefs.

References

Campbell, P. F. & Malkus, N. N. (2009). *School improvement through elementary mathematics coaches: Impact on teacher beliefs and student achievement.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA, April 13-17, 2009.

Chafel, J. A. (2003). Socially constructing concepts of self and other through play. *International Journal of Early Years Education, 11(3),* 213-222.

Clements, D. H. & Sarama, J. (2007). Early childhood mathematics learning. In F. K. Lester (Ed.) *Second Handbook of research on mathematics teaching and learning* (pp. 461-555). New York: Information Age Publishing.

Conference Board of the Mathematical Sciences (CBMS). (2001). *The mathematical education of teachers*. CBMS series on *Issues in mathematics education*, Vol. #11. Providence, RI: American Mathematical Society.

Copley, J. V., Ed. (1999). *Mathematics in the early years*. Washington, DC: National Association for the Education of Young Children.

De Corte, E., & Verschaffel, L. (2006). Mathematical thinking and learning. In K.A. Renninger and I.E. Sigel (eds.), *Handbook of child psychology, sixth edition, Volume 4: Child psychology in practice* (pp. 103-152). New York: Wiley.

Findell, B., Brosnan, P., & Erchick, D. (2008). *Mathematics coaching program: Report to the Ohio Department of Education.* Columbus, OH: The Ohio State University Mathematics Coaching Program.

Ginsburg, H. P., Lee, J. S., & Boyd, J. S. (2008). Mathematics education for young children: What it is and how to promote it. *Social Policy Report, Society for Research in Child Development, 22*(1), 1-24.

Kilpatrick, J., Swafford, J., & Findell, B., (Eds.). (2001). *Adding it up: Helping children learn mathematics*. Mathematics Learning Study Committee, Washington, D.C.: National Research Council.

Marsh, H. W., Craven, R. G., & Debus, R. (1991). Self-concepts of young children 5 to 8 years of age: Measurement and multidimensional structure. *Journal of Educational Psychology, 83*, 377-392.

National Association for the Education of Young Children and National Council of Teachers of Mathematics. (2002). Position statement. *Early childhood mathematics: Promoting good beginnings.* From http://www.naeyc.org/about/positions/psmath.asp

Reys, B. J., & Fennell, F. (2003). Who should lead mathematics instruction at the elementary school level? A case for mathematics specialists. *Teaching children mathematics* (277-279). Reston, VA: National Council of Teachers of Mathematics.

Sheridan, S. S., Edwards, C. P., Clarke, B., & Knoche, L. (2009). Professional Development in Early Childhood: Current Status and Research Needs. In Sheridan, S., & Edwards, C. P. Guest Editors, Early Education & Development, *Special Issue on Professional Development in Early Childhood: Empirical Findings from the Interagency School Readiness Consortium.*

West, L., & Staub, F. C. (2003). *Content-focused coaching: Transforming mathematics lessons.* Portsmouth, NH: Heinemann.