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RESPONSE TO COMMENTARIES

Early Childhood Mathematics Education: The Critical Issue is Change

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I chose the term *revolution* because it comes from the Latin word *revolutio,* which means ''a turn around.'' Leading researchers in the early 20th century were advocating that young children were mathematically inept and that mathematics education was useless before elementary school (Thorndike, 1922). Today, a large body of developmental research advocates that young children are born mathematicians and that early childhood mathematics education (ECME) is vital (Cross, Woods, & Schweingruber, 2009; Geist, 2009). Comparing these stances, it is fair to say that we have indeed turned around—a full 180 degrees, in fact. But Stipek's (2013) point is also correct. The rebirth of cognitive psychology in the 1960s, and the development of Head Start, with its purpose of giving disadvantaged children an academic leg up, saw the beginning of foundational research that focused on the mathematical capabilities (rather than the lack of mathematical aptitude) of young children. And with early childhood mathematics content now having grown to include five core knowledge areas and numerous thinking and behavior processes, what we have witnessed could be viewed as an evolution—as *evolution* comes from the Latin word *ēvolūtiō,* meaning ''unfolding or unrolling,'' and is usually conceived as the development of something from a simple to more complex form.

Although one should certainly acknowledge the importance of the early work in the field in the latter half of the last century, before the turn of this century there was still a general deemphasis of ECME outside of Stipek's ''small club'' and Head Start (Balfanz, 1999; Geary, 1996; Ginsburg & Golbeck, 2004; Sophian, 2004). However, research in only the past decade or so (by many of the people in the club) has spawned a drastic shift in paradigm (i.e., a tangible turn around) in the prevailing thought about what early mathematics is and what ECME should be. This is substantiated by the recent growth of state preschool mathematics guidelines and standards; the advent of major position papers by the National Association for the Education of Young Children, the National Council of Teachers of Mathematics, and the National

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Academies Press; and the recent surge in developmental research–based early math curricula. Whether this shift in the 21st century is radical enough to be termed an ECME *revolution* or is just a major jump in ECME *evolution* remains up for debate.

Semantics aside, at the heart of both revolution and evolution is the idea of *change*. More important, hopefully change for the better. Sophian (2013) also takes up this idea in her commentary. Her chosen term, *vicissitude,* comes from the Latin *vicis,* which literally translates to ''change.'' More specifically, it refers to a fluctuation of state or mutability in the development of something, especially related to successive alternation from one condition to another. Sophian's (2013) commentary speaks to change three-fold, all providing, I believe, support for the need for intentional ECME.

First, she looks at mathematical conceptual change in young children and notes that the early mathematical knowledge of young children is often fragile and has limitations. I agree that this is an important distinction to make. Although children are much more capable mathematically than previously supposed, their early conceptualizations are, not surprisingly, child-like. Research holds that young children do exhibit amazing intuitive mathematical knowledge, and yet the studies that Sophian (2013) cites also provide evidence that young children are prone to misconceptions. Furthermore, as is the case with any novice, early mathematical thinking is often characterized by a lack of transfer and the Einstellung effect (a predisposition to solve a given problem in a specific learned manner even though more appropriate methods of solving the problem exist). This directly points to the need for intentional, high-quality ECME to help build young children's fragile intuitive knowledge into the robust and generalizable knowledge that marks more sophisticated mathematical thinking.

Second, Sophian (2013) contends that ECME can serve to change these early mathematical misconceptions by not only carefully considering short-term objectives but also tracing the long-term goals of mathematics education. I see this as a call for the early childhood teacher to have a deep knowledge base about mathematics and mathematics knowledge development. It echoes Stipek's discussion on the complex task of the early childhood teacher in engaging in high-level ECME. Third, and perhaps most important, Sophian (2013) demonstrates how developmental research can be used to change, in this case shape and advance, early childhood mathematics instructional practice by applying research findings. I believe that her commentary emphasizes my point that there is a strong need today to translate what researchers now know about young children's early mathematics knowledge development into optimal instructional methods that can be used to guide the early childhood teacher in the classroom.

Both Stipek and I agree that there are major hurdles holding back substantial change in ECME teaching practice. First, the water is muddied by the general confusing of the kind of intentional ECME advocated by researchers today and the didactic drill-and-kill ways of instruction that have qualified as mathematics education in practice since the late 1960s. Sophian (2013) refers to the positive benefits of practice, which are well documented in the cognitive literature devoted to the development of expertise in any knowledge context. However, when discussing practice, she is not referring to a drill-and-kill way that focuses on rote memorization, as some might be prone to misconstrue. Instead, Sophian (2013) is addressing the need for repeated exposure to diverse and meaningful mathematically based problem solving—specifically, the type of problem solving that allows for the practice of thinking and behavior processes that encourage young children to reason and explain, leading to deep conceptual understanding. I share Stipek's concern that the recent surge in attention on ECME may encourage those who jump in to fall back on the easier-to-implement, traditional ways of teaching (rote counting exercises, dittos, etc.) that are counter to the meaningful, real-world types of

mathematical problem solving that actually build foundational mathematics knowledge and skills (Cross et al., 2009; Hachey, in press). Continuation, or even worse expansion, of traditional practices that focus on memorization and assessment masks the true essence of mathematics (as a way to organize and communicate about the natural world). It will likely turn young children away from their intuitive interest in mathematics, with the potential of doing more harm than good (Hachey, 2009).

Second, we agree that change in practice is being held back by the need for early childhood teachers to be better prepared; as Stipek labels it, there is a desperate need for ''capacity building.'' What recent work in the field, both the teaching–learning pathways approach (Clements & Sarama, 2009; Cross et al., 2009; Sarama & Clements, 2009) and the microgenetic/conceptual change research, such as that highlighted by Sophian (2013), has given us a better understanding of *what* to teach young children and *how* to teach them about mathematics. This research offers critical guidance in how to teach young children in ways that match developmental levels, ways that build academic knowledge and skills that can become robust and generalizable and yet provide ways that still support their interest and social-emotional development. But until more research is distilled to provide specific ways of using developmental evidence to guide instruction (as is demonstrated in Sophian's, 2013, commentary), and until an infrastructure is in place that trains early childhood teachers to actually *become* teachers of mathematics (as Stipek and I discuss), real change in teaching practice (whether as vicissitudes in the ECME field, as the conclusion of an ECME revolution, or as the next stage in ECME evolution) will not happen. Call it what you will, it is time for all of us not only to knock on the ECME clubhouse door but to build up a new one.

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